UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS TX 75202-2733

SEP 3 0 2014

CERTIFIED MAIL-RETURN RECEIPT REQUESTED

Mr. Thomas E. Lederle, Chief
Army BRAC Office
ATTN: Tom Lederle (DAIM-BD)
600 Army Pentagon
Washington, DC 20310-0600

Re: Final Five-Year Review Report
Third Five-Year Review
Longhorn Army Ammunition Plant, Karnack, Texas

Dear Mr. Lederle:

This letter documents that the U.S. Environmental Protection Agency's (EPA's) does not concur with the Army's protectiveness determinations in the *Final 2013 Five-Year Review Report for Longhorn Army Ammunition Plant, Karnack, Texas,* dated May 2014. Currently, the remedies are protective in the short-term. The remedies will be considered protective in the long-term if the recommendations and follow up actions of the five-year review, including any actions necessitated by the EPA Administrator's decision from the Longhorn formal dispute, are implemented.

This is the third five-year review for the Longhorn Army Ammunition Plant (LHAAP), which was triggered due to the implementation of remedial action at the LHAAP in 1997, the completion of the first five-year review in 2002, and the completion of the second five year review in 2008. This Five-Year Review Report was submitted as draft by the Army in August 2013, reviewed and commented by the State of Texas in September 2013 and EPA in December 2013, and was submitted as final by the Army in May 2014.

The five-year review is required by Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA), 42 U.S.C. § 9621(c), and by Section 300.430 (f) (4) (ii) of the National Oil and Hazardous Substance Contingency Plan (NCP), which require that a periodic review be conducted no less often than every five years after the initiation of remedial action at sites where hazardous substances, pollutants, or contaminants will remain onsite above levels that allow for unlimited use and unrestricted exposure. The Army, as lead agency for LHAAP, conducted this review. According to EPA's Comprehensive Five-Year Review Guidance (OSWER No. 9355.7-03B-P, June 2001), EPA's role as the final remedy selection authority at an NPL site under the jurisdiction of another Federal agency or department requires that EPA retain final authority to make protectiveness determinations in connection with the site. Accordingly, EPA Regions are to review Federal facility NPL Five-Year Review reports and protectiveness determinations for consistency with EPA's Comprehensive Five-Year Review Guidance and the adequacy of the supporting basis; should participate or comment throughout the five-year review process; and as appropriate the EPA will either concur with any protectiveness determinations to ensure protectiveness of human health and the environment, or EPA may provide independent findings. In this case, the Army provided EPA with a draft Five-Year Review Report and EPA responded with comments and recommendations. This is EPA's review of the final Five-Year Review Report for LHAAP prepared by the Army.

The final Five-Year Review Report documents the results of the third five-year review of remedial actions implemented at LHAAP and evaluates whether the following remedial actions are protective of human health and the environment:

- Final Remedial Action (RA) at LHAAP-12
- Early Interim Remedial Action (IRA) at LHAAP-16
- IRA at LHAAP-18/24
- No Action Alternative at LHAAP-49
- No Further Action (NFA) at LHAAP-004-R-01 (Pistol Range)

In regards to remedies and remedial actions at all LHAAP sites: Currently, there is a formal dispute awaiting the EPA Administrator's decision. The dispute involves groundwater and land use control (LUC) issues, which impacts long-term protectiveness at LHAAP. Upon issuance of the EPA Administrator's decision, any actions necessitated by the decision must be integrated and implemented to ensure long-term protectiveness at LHAAP.

In regards to LHAAP-12: The Final RA (cap, LUCs and MNA) at LHAAP-12 currently protects human health and the environment in the short-term by reducing the leaching and migration of hazardous substances, preventing contaminated groundwater from migrating to surface water, and preventing human exposure to contaminated groundwater. Replacement of well 12WW24 and an evaluation of whether expansion of the current monitoring well network and re-evaluation of possible seasonal effect on VOC concentrations and groundwater flow will enhance long-term protectiveness.

In regards to LHAAP-16: The IRA remedy at LHAAP-16 currently protects human health and the environment in the short-term because the cap and an extraction system, which is part of a Treatability Study, combined with LUCs prevent direct exposure pathway to landfill material, reduce contaminant transport and mass of contaminants in the groundwater. Additionally the groundwater monitoring program assures prevention of exposure. The final remedy, documented in the Draft Final Record of Decision, includes the IRA cap, in-situ bioremediation, biobarriers, and additional LUCs such as groundwater use restrictions is expected to be protective of human health and the environment upon completion. In-situ bioremediation and biobarriers in the final remedy will mitigate the potential for contaminants to seep into Harrison Bayou at unacceptable levels.

In regards to LHAAP-18/24: The IRA at LHAAP-18/24 currently protects human health and the environment in the short-term because the excavation of source material has removed the source, and the extraction and treatment of groundwater mitigates plume migration and has resulted in reductions in contaminant levels since implemented. A revised feasibility study is currently under development and will address the additional sampling needed for data gap analysis and a conceptual site model update. Implementation of the final remedy will also include an evaluation of the existing groundwater extraction and treatment system, LUCs, and MNA to ensure protectiveness.

In regards to LHAAP-49: The No Action Alternative at LHAAP-49 is currently protective of human health and the environment in the short-term because the risk evaluation conducted determined that the site is suitable for non-residential use and compatible with anticipated future land use as a national wildlife refuge.

In regards to LHAAP-004-R-01 (Pistol Range): The NFA at the former Pistol Range is currently protective of human health and the environment in the short-term because the earlier non-time-critical removal action made the site compatible with the anticipated future land use as a national wildlife refuge.

The five-year review report details recommendations and follow up actions that the Army must implement, in accordance with the Federal Facility Agreement for LHAAP. Currently, the remedies are protective in the short-term. The remedies will be considered protective in the long-term if the recommendations and follow up actions of the five-year review, including any actions necessitated by the EPA Administrator's decision from the Longhorn formal dispute, are implemented. If there are any questions regarding this matter, please feel free to contact Mr. John Meyer, of my staff, at (214) 665.6742.

Sincerely yours,

Pam Phillips, Acting

Carl Edlund, P.E.
Director
Superfund Division

cc: Charlotte Bertrand, Acting Director
EPA Federal Facilities Restoration and Reuse Office

Joy Nicholopoulos, Deputy Regional Director,
U.S. Fish and Wildlife Service, Region 2

Beth Seaton, Director
TCEQ Remediation Division, Office of Waste

FINAL
2013 FIVE-YEAR REVIEW REPORT
FOR
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

Prepared For:

U.S. Army Corps of Engineers

Prepared By:

AECOM Technical Services

May 2014

FINAL

2013 FIVE-YEAR REVIEW REPORT

FOR

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

Prepared For:

U.S. Army Corp of Engineers

Tulsa District

Prepared By:

AECOM Technical Services

Contract No. W912DY-09-D-0059

Task Order No. DS01

May 2014

Approved By:

Rose M. Zeiler

Dr. Rose M. Zeiler, Ph.D.
Longhorn AAP Site Manager

May 15, 2014
Date

Table of Contents

EXECUTIVE SUMMARY .... *xi*

1 *INTRODUCTION* *1-1*

2 *LHAAP GENERAL BACKGROUND* *2-1*

2.1 **General LHAAP Physical Characteristics and History** **2-1**

2.2 **General LHAAP Geologic and Hydrogeologic Setting** **2-2**

2.3 **General LHAAP Land and Groundwater Use** **2-2**
2.3.1 Land 2-3
2.3.2 Groundwater 2-3

3 *LHAAP-12* *3-1*

3.1 **Site Chronology** **3-1**

3.2 **History of Contamination** **3-2**

3.3 **Initial Response** **3-2**

3.4 **Basis for Taking Action** **3-3**

3.5 **Remedial Actions** **3-4**
3.5.1 Regulatory Basis for Action 3-4
3.5.2 Remedial Action Objectives 3-5
3.5.3 Remedy Description 3-5
3.5.4 Remedy Implementation 3-6

3.6 **Compliance Monitoring** **3-7**

3.7 **Systems Operations and Maintenance** **3-8**
3.7.1 Treatment or Other System Processes 3-8
3.7.2 Operations and Maintenance Costs 3-8

3.8 **Progress Since the Last Five-Year Review** **3-9**
3.8.1 Previous Protectiveness Statements and Recommended Actions 3-9
3.8.2 Status of Ongoing Activities 3-12

3.9 **Five-Year Review Component** **3-13**
3.9.1 Administrative Review 3-13
3.9.2 Community Involvement 3-14
3.9.3 Document Review 3-14
3.9.4 Data Review 3-14
3.9.4.1 Potentiometric Surface 3-14
3.9.4.2 Contaminants 3-14
3.9.5 Site Inspection 3-16
3.9.6 Interview Summary 3-17

3.10 **Technical Assessment** **3-17**
3.10.1 Question A: Is the remedy functioning as intended by the decision documents? 3-17

3.10.2 Question B: Are the assumptions used at the time of remedy selection still valid? 3-19
3.10.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy? 3-21

3.11 Issues 3-21
3.11.1 Issues Identified during the Technical Assessment and Other Five-Year Review Activities 3-21
3.11.2 Determination of Whether Issues Affect Current or Future Protectiveness 3-21
3.11.3 Unresolved Issues 3-22

3.12 Recommendations and Follow-up Actions 3-22

3.13 Protectiveness Summary 3-22

3.14 Next Review 3-22

4 LHAAP-16 4-1

4.1 Site Chronology 4-1

4.2 History of Contamination 4-2

4.3 Initial Response 4-3

4.4 Basis for Taking Action 4-3

4.5 Remedial Actions 4-4
4.5.1 Regulatory Basis for Action 4-4
4.5.2 Remedial Action Objectives 4-4
4.5.3 Remedy Description 4-4
4.5.4 Remedy Implementation 4-5

4.6 Compliance Monitoring 4-6

4.7 Systems Operations and Maintenance 4-6
4.7.1 Treatment or Other System Processes 4-7
4.7.2 Operations and Maintenance Costs 4-8

4.8 Progress Since the Last Five-Year Review 4-8
4.8.1 Previous Protectiveness Statements and Recommended Actions 4-8
4.8.2 Status of Ongoing Activities 4-12

4.9 Five-Year Review Component 4-13
4.9.1 Administrative Review 4-13
4.9.2 Community Involvement 4-13
4.9.3 Document Review 4-14
4.9.4 Data Review 4-14
4.9.4.1 Potentiometric Surface 4-14
4.9.4.2 Contaminants 4-14
4.9.5 Site Inspection 4-17
4.9.6 Interview Summary 4-18

4.10 Technical Assessment 4-18

4.10.1 Question A: Is the remedy functioning as intended by the decision documents? 4-18
4.10.2 Question B: Are the assumptions used at the time of remedy selection still valid? 4-20
4.10.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy 4-20

4.11 Issues 4-21
4.11.1 Issues Identified during the Technical Assessment and Other Five-Year Review Activities 4-21
4.11.2 Determination of Whether Issues Affect Current or Future Protectiveness 4-21
4.11.3 Unresolved Issues 4-21

4.12 Recommendations and Follow-up Actions 4-21

4.13 Protectiveness Summary 4-21

5 LHAAP 18/24 5-1

5.1 Site Chronology 5-1

5.2 History of Contamination 5-3

5.3 Initial Response 5-3

5.4 Basis for Taking Action 5-4

5.5 Remedial Actions 5-4
5.5.1 Regulatory Basis for Action 5-4
5.5.2 Remedial Action Objectives 5-4
5.5.3 Remedy Description 5-5
5.5.4 Remedy Implementation 5-5
5.5.4.1 Groundwater Extraction and Treatment 5-5
5.5.4.2 Excavation and Treatment of Source Material 5-5

5.6 Compliance Monitoring 5-6

5.7 Systems Operations and Maintenance 5-6
5.7.1 Treatment or Other System Processes 5-7
5.7.2 System Operations and Maintenance 5-9
5.7.2.1 Major Maintenance 5-9
5.7.2.2 Groundwater Extracted by the GWTP and LHAAP-16 Systems 5-9
5.7.3 Issues Impacting Performance 5-10
5.7.3.1 Catalytic Oxidation Scrubber 5-10
5.7.3.2 Pump and PLC Cable Severing at LHAAP-16 5-10
5.7.3.3 Materials Balance 5-11
5.7.3.4 Re-injection 5-11
5.7.4 Groundwater Treatment Plant Sampling and Analysis 5-12
5.7.5 Groundwater Monitoring 5-12
5.7.6 Operations and Maintenance Conclusions 5-13
5.7.7 Operations and Maintenance Costs 5-14

5.8 Progress Since the Last Five Year Review 5-14

5.8.1 Previous Protectiveness Statements and Recommended Actions 5-15
5.8.2 Status of Ongoing Activities 5-18

5.9 Five-Year Review Component 5-18
5.9.1 Administrative Review 5-18
5.9.2 Community Involvement 5-19
5.9.3 Document Review 5-19
5.9.4 Data Review 5-20
5.9.4.1 Potentiometric Surface 5-20
5.9.5 Site Inspection 5-27
5.9.6 Interview Summary 5-28

5.10 Technical Assessment 5-29
5.10.1 Question A: Is the remedy functioning as intended by the decision documents? 5-29
5.10.2 Question B: Are the assumptions used at the time of remedy selection still valid? 5-30
5.10.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy 5-31

5.11 Issues 5-31
5.11.1 Issues Identified during the Technical Assessment and Other Five-year Review Activities 5-31
5.11.2 Determination of Whether Issues affect Current or Future Protectiveness 5-32
5.11.3 Unresolved Issues 5-32

5.12 Recommendations and Follow-up Actions 5-32

5.13 Protectiveness Summary 5-32

6 LHAAP-49 FORMER ACID STORAGE AREA 6-1

6.1 Site Chronology 6-1

6.2 History of Contamination 6-1

6.3 Initial Response 6-1

6.4 Basis for Taking Action 6-2

6.5 Remedial Actions 6-4
6.5.1 Regulatory Basis for Action 6-4
6.5.2 Remedial Action Objectives 6-4
6.5.3 Remedy Description 6-4
6.5.4 Remedy Implementation 6-4

6.6 Compliance Monitoring 6-4

6.7 Systems Operations and Maintenance 6-4

6.8 Progress Since the Last Five Year Review 6-4
6.8.1 Previous Protectiveness Statements and Recommended Action 6-4
6.8.2 Status of Ongoing Activities 6-4

6.9 Five-Year Review Component 6-5

6.9.1 Administrative Review 6-5
6.9.2 Community Involvement 6-5
6.9.3 Document Review 6-6
6.9.4 Site Inspection 6-6
6.9.5 Interview Summary 6-6

6.10 Technical Assessment 6-6

6.11 Protectiveness Summary 6-6

7 FORMER PISTOL RANGE (LHAAP-004-R-01) 7-1

7.1 Site Chronology 7-1

7.2 History of Contamination 7-1

7.3 Initial Response 7-2

7.4 Basis for Taking Action 7-2

7.5 Remedial Actions 7-2
7.5.1 Regulatory Basis for Action 7-2
7.5.2 Remedial Action Objectives 7-3
7.5.3 Remedy Description 7-3
7.5.4 Remedy Implementation 7-3

7.6 Compliance Monitoring 7-3

7.7 Systems Operations and Maintenance 7-3

7.8 Progress Since the Last Five Year Review 7-3
7.8.1 Previous Protectiveness Statements and Recommended Actions 7-3
7.8.2 Status of Ongoing Activities 7-3

7.9 Five-Year Review Component 7-3
7.9.1 Administrative Review 7-3
7.9.2 Community Involvement 7-4
7.9.3 Document Review 7-4
7.9.4 Site Inspection 7-5
7.9.5 Interview Summary 7-5

7.10 Technical Assessment 7-5

7.11 Protectiveness Summary 7-5

8 NEXT REVIEW 8-1

9 REFERENCES 9-1

List of Figures

Figure 2-1: LHAAP and Site Location Map

Figure 3-1: Groundwater Use Restriction Area – LHAAP-12

Figure 3-2: 2009 Groundwater Contamination Plume Map – LHAAP-12

Figure 4-1: Extent of Groundwater Contamination and Well Locations - LHAAP-16

Figure 5-1: Water Treated Monthly from October 2008 through March 2013

Figure 5-2: Treated Water Injected in LHAAP-18/24 from September 2007 through March 2013

Figure 5-3: Quarterly Extraction Rate

Figure 5-4: Site Features and Historical Contaminant Sources – LHAAP-18/24

Figure 5-5: Site Area Layout of ICTs and GWTP Location – LHAAP-18/24

List of Tables

Table ES-1: Overview of LHAAP Sites

Table 3-1: Chronology of Site Events for LHAAP-12[1]

Table 3-2: O&M and LTM Costs for LHAAP-12, LHAAP-16 and LHAAP-18/24

Table 3-3: Protectiveness Statements from Previous Reviews

Table 3-4: Recommendations for LHAAP-12 from Previous Reviews

Table 3-5: Five-Year Review Team

Table 3-6: TCE Concentrations (μg/L) at Monitoring Wells at LHAAP-12[1]

Table 3-7: Concentrations (μg/L) of Degradation Products at 12WW24[1]

Table 3-8: Groundwater Cleanup Levels Comparison for LHAAP-12, Landfill 12

Table 3-9: Recommendations/Follow-up Actions for LHAAP-12

Table 4-1: Chronology of Site Events for LHAAP-16[1]

Table 4-2: O&M and LTM Costs for LHAAP-12, LHAAP-16 and LHAAP-18/24

Table 4-3: Protectiveness Statements from Previous Reviews

Table 4-4: Recommendations for LHAAP-16 from Previous Reviews

Table 4-5: Five-Year Review Team

Table 4-6: TCE Concentrations (μg/L) in Extraction Wells

Table 4-7: Perchlorate Concentrations (μg/L) in Extraction Wells

Table 4-8: TCE Concentrations (μg/L) in the Shallow Zone Monitoring Wells

Table 4-9: Perchlorate Concentrations (μg/L) in the Shallow Zone Monitoring Wells

Table 4-10: Recommendations/Follow-up Actions for LHAAP-16

Table 5-1: Chronology of Site Events for LHAAP-18/24

Table 5-2: O&M and LTM Costs for LHAAP-12, LHAAP-16 and LHAAP-18/24

Table 5-3: Protectiveness Statements from Previous Five-Year Reviews LHAAP-018/024

Table 5-4: Recommendations for LHAAP-18/24 from Previous Reviews

Table 5-5: Five-Year Review Team

Table 5-6: Methylene Chloride Concentrations (µg/L) in Monitoring Wells

Table 5-7: Trichloroethene Concentrations (µg/L) in Monitoring Wells

Table 5-8: Perchlorate Concentrations (µg/L) in Monitoring Wells

Table 5-9: Recommendations/Follow-up Actions for LHAAP-18/24

Table 6-1: Chronology of Site Events for LHAAP-49

Table 6-2: Five-Year Review Team

Table 7-1: Chronology of Site Events for former Pistol Range

Table 7-2: Five-Year Review Team

List of Appendices

APPENDIX A: Not Used

APPENDIX B: Public Notice

APPENDIX C: Applicable or Relevant and Appropriate Requirements

APPENDIX D: LHAAP-12 Supporting Documents

APPENDIX E: LHAAP-16 Supporting Documents

APPENDIX F: LHAAP 18/24 Supporting Documents

APPENDIX G: LHAAP-49 Supporting Documents

APPENDIX H: Pistol Range Supporting Documents

APPENDIX I: Interview Forms

Acronyms and Abbreviations

°F	degrees Fahrenheit
µg/L	micrograms per liter
§	Section
AECOM	AECOM Technical Services, Inc.
AEHA	U.S. Army Environmental Hygiene Agency
A/I	active/inactive
ARAR	applicable or relevant and appropriate requirements
BERA	Baseline Ecological Risk Assessment
BG3	burning ground number 3
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CES	Complete Environmental Service, Inc.
COC	contaminant of concern
COPC	chemical of potential concern
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid
DOW	Dow Environmental, Inc.
DPT	direct push technology
EE/CA	Engineering Evaluation/Cost Analysis
EPS	Environmental Protection Systems
ESD	Explanation of Significant Differences
FFA	Federal Facility Agreement
FS	Feasibility Study
gpm	gallons per minute
GWTP	groundwater treatment plant
HASP	Health and Safety Plan
HI	hazard index
ICT	interception collection trench
INF	Intermediate-Range Nuclear Forces
IRA	Interim Remedial Action

Jacobs	Jacobs Engineering Group, Inc.
LHAAP	Longhorn Army Ammunition Plant
LTM	Long-Term Monitoring
LTTD	low temperature thermal desorption
LUC	Land Use Control
MC	methylene chloride
MCL	maximum contaminant level
mg/kg	milligrams per kilograms
MNA	monitored natural attenuation
MSC	medium specific concentration
msl	mean sea level
NAPL	non-aqueous phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	No Further Action
NPL	National Priorities List
O&M	Operation and Maintenance
OPS	Operating Properly and Successfully
Plexus	Plexus Scientific Corp.
PVC	polyvinyl chloride
RA	Remedial Action
RAB	Restoration Advisory Board
Radian	Radian International, LLC.
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RGO	remedial goal options
RI	Remedial Investigation
ROD	Record of Decision
SAI-Ind	Soil/Air and Ingestion Standard for Industrial
SAP	Sampling and Analysis Plan
Shaw	Shaw Environmental, Inc.

SI	Site Inspection
SLERA	Screening-Level Ecological Risk Evaluation
STEP	Solutions To Environmental Problems, Inc.
TAC	Texas Administrative Code
TBC	to be considered
TCDD	tetrachlorodibenzo-p-dioxin
TCE	trichloroethene
TCEQ	Texas Commission on Environmental Quality
TNRCC	Texas Natural Resource Conservation Commission
TNT	trinitrotoluene
TS	Treatability Study
UEP	unlined evaporation pond
U.S.	United States
U.S. Army	U.S. Department of the Army
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VC	vinyl chloride
VOC	volatile organic compound
WP	Work Plan

EXECUTIVE SUMMARY

This report documents the results of the five-year review of Remedial Actions (RAs) implemented at multiple sites located at Longhorn Army Ammunition Plant (LHAAP) in Karnack, Texas. The Five-Year Review was conducted from November, 2012 to January, 2013 by the U.S. (United States) Department of the Army (U.S. Army) in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). A Site Inspection (SI) was conducted on January 8, 2013 to support this review. The purpose of the Five-Year Review is to evaluate whether the RAs implemented at various sites at LHAAP are protective of human health and the environment. This report includes a detailed evaluation for the six response action sites with either an Interim Remedial Action (IRA) or final remedy in place. The response actions for the six sites are:

- Final RA at LHAAP-12
- Early IRA at LHAAP-16
- IRA at LHAAP-18/24
- No Action Alternative at LHAAP-49 and No Further Action (NFA) at LHAAP-004-R-01 (Pistol Range)

An overview of these sites is presented in Table ES-1.

Table ES-1: Overview of LHAAP Sites

Site	Description	Date of ROD	COCs/COPCs on the Basis of Industrial Land Use	Selected Remedy
LHAAP-12	The landfill was used for disposal of non- hazardous industrial waste between 1963 and 1994.	IRA - September 1995 Final - April 2006	TCE	Landfill cap, LUCs, and MNA
LHAAP-16	The landfill was used for disposal of trinitrotoluene (TNT) red water ash from 1942 to 1944. Burn pits, waste storage, and landfill operations continued until 1980s.	IRA-September 1995	None identified in the IRA	Landfill cap, LUCs Final Remedy in decision phase
LHAAP-18/24	Site 24was a UEP located within the former burning ground number 3 (BG3), Site 18. The burning ground site was used from approximately 1955 until 1984 for the treatment, storage, and disposal of pyrotechnic and combustible solvent wastes by open burning, incineration, evaporation, and burial. The UEP was constructed in 1963 and used until 1984 for disposal of manufacturing plant waste.	IRA ROD May 1995	VOCs and metals[a,b]	Extraction of shallow groundwater and treatment using metal precipitation, air stripping and off-gas treatment for VOCs, Excavation of source material and treatment using low thermal desorption and off-gas treatment for VOCs. Final Remedy in planning phase.

Site	Description	Date of ROD	COCs/COPCs on the Basis of Industrial Land Use	Selected Remedy
LHAAP-49	This site was used from 1942 to 1945 for formulation and storage of acid in support of TNT production.	September 2010	None	No Action
LHAAP-004-R-01 (Pistol Range)	This site was used between 1950 and 2004 for small arms target practice and qualifying tests.	August 2010	None	No Further Action (NFA)

Notes:
[a] Perchlorate was identified at levels of concern following IRA implementation at LHAAP-16 and LHAAP-18/24.
[b] IRA specified discharge limits, not COCs.
COC contaminant of concern
COPC chemical of potential concern
IRA Interim Remedial Action
LHAAP Longhorn Army Ammunition Plant
LUC Land Use Control
MNA monitored natural attenuation
NFA No Further Action
ROD Record of Decision
TCE trichloroethene
UEP unlined evaporation pond
VOC volatile organic compound

For the above sites, the Technical Assessment completed as part of the Five-Year Review determined the following:

- The remedy is functioning as intended or is actively being reviewed for modification/final remedy implementation.
- The assumptions used at the time of remedy selection remain valid, and the Remedial Action Objectives (RAOs) are still appropriate.
- No other information was encountered that calls into question the protectiveness of the remedy.
- For the NA or NFA sites, non-residential use was confirmed as was the continued use of the property as a National Wildlife Refuge

Based on the technical assessment, recommendations were provided to close any data gaps and improve the effectiveness of the RAs in protecting human health and the environment. The Issues, Recommendations and Follow-up Actions, and Protectiveness Statements for each site are summarized in the Five-Year Review Summary Forms which follow this Executive Summary.

Five-Year Review Summary Form - Sites LHAAP-12, LHAAP-16, LHAAP-18/24

SITE IDENTIFICATION		
Site Name: Longhorn Army Ammunition Plant		
USEPA ID: TX6213820529		
Region: 6	**State:** TX	**City/County:** Karnack, Harrison

SITE STATUS	
National Priorities List (NPL) Status: Final	
Multiple Sites? Yes	**Has the site achieved construction completion?** Yes (LHAAP-12) No (LHAAP-16 & LHAAP-18/24)

REVIEW STATUS
Lead agency: Other Federal Agency - U.S. Army
Author name (Federal or State Project Manager): Rose Zeiler
Author affiliation: Installation Manager
Review period: November 2012 - January 2013
Date of Site Inspection (SI): January 8, 2013
Type of review: Statutory
Review number: 3
Triggering action date: October 2, 2008
Due date *(five years after triggering action date)*: October 2, 2013

Issues/Recommendations

Issues and Recommendations Identified in the Five-Year Review:

Site: LHAAP-12	**Issue Category:** Remedy Performance			
	Issue: Possible seasonal effects in volatile organic compound (VOC) concentrations not understood from the original eight quarters of data. Plume area water level measurements might not adequately depict groundwater gradient, the well within the plume was dry in 2012, and monitored natural attenuation (MNA) evaluation is limited to the one well within the plume			
	Recommendation: Expand MNA network to include installing at least one additional well in the plume, re-evaluate and expand wells where water level measurements are taken, and re-evaluate the MNA network			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	U.S. Army	USEPA/State	01 July 2014

Site: LHAAP-16	**Issue Category:** Operations and Maintenance			
	Issue: Need a separate Operation and Maintenance (O&M) Plan for Site 16			
	Recommendation: Separate the O&M Plan for Site 16 from the Site 18/24 groundwater treatment plant (GWTP) O&M Plan			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	U.S. Army	USEPA/State	01 July 2014, and final remedy completion date

Site: LHAAP-18/24	**Issue Category:** Remedy Performance			
	Issue: Some potential ICT issues, which could cause off-site migration, need assessment. Some ICTs are too shallow for capture. Rare perchlorate discharge from plant exceeding concentrations.			
	Recommendation: Implement final remedy once Record of Decision (ROD) is approved and collect data from down gradient locations to continue to monitor concentrations pending finalization of the ROD. Once further data is collected, source removal may need to be implemented at other areas of the site.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	U.S. Army	USEPA/State	01 July 2014 and final remedy completion date

Protectiveness Statement(s)		
Site: LHAAP-12	**Protectiveness Determination:** Protective	**Addendum Due Date (if applicable):** Click here to enter date.

Protectiveness Statement:
The Final RA (cap, Land Use Controls [LUCs] and MNA) at LHAAP-12 currently protects human health and the environment by reducing the leaching and migration of hazardous substances, preventing contaminated groundwater from migrating to surface water, and preventing human exposure to contaminated groundwater. The re-evaluation and potential expansion of the current monitoring well network and review of possible seasonal effect on VOC concentrations and groundwater flow will ensure long-term protectiveness.

Protectiveness Statement(s)		
Site: LHAAP-16	**Protectiveness Determination:** Protective	**Addendum Due Date (if applicable):** Click here to enter date.

Protectiveness Statement:
The IRA remedy at LHAAP-16 currently protects human health and the environment because the cap combined with LUCs augmented by a treatability study extraction system preventing direct exposure to landfill material, reduce contaminant transport and mass of contaminants in the groundwater. The final remedy inclusive of the IRA cap, In-situ bioremediation/biobarriers, and additional LUCs such as groundwater use restrictions are expected to be protective of human health and the environment once implemented.

Protectiveness Statement(s)		
Site: LHAAP-18/24	**Protectiveness Determination:** Protective	**Addendum Due Date (if applicable):** Click here to enter date.

Protectiveness Statement:
The IRA at LHAAP-18/24 currently protects human health and the environment because the excavation of source material has removed the source (pending confirmation by in-progress Revised FS including new information developed in 2013), and the extraction and treatment of groundwater mitigates plume migration. However, in order for the remedy to be protective in the long-term, the following actions are already underway or planned by The U.S. Army to ensure protectiveness:

- Completed additional well installation and sampling in 2013 with a Data Gap Report and Revised FS in-progress
- Updating the CSM; and
- Implement final remedy, which will likely include an evaluation of the existing groundwater extraction and treatment system, possible LUCs, and MNA.

Five-Year Review Summary Form - Sites LHAAP-49 and LHAAP004-R-01

<table>
<tr><th colspan="3">SITE IDENTIFICATION</th></tr>
<tr><td colspan="3">Site Name: Longhorn Army Ammunition Plant</td></tr>
<tr><td colspan="3">USEPA ID: TX6213820529</td></tr>
<tr><td>Region: 6</td><td>State: TX</td><td>City/County: Karnack, Harrison</td></tr>
<tr><th colspan="3">SITE STATUS</th></tr>
<tr><td colspan="3">NPL Status: Final</td></tr>
<tr><td>Multiple Sites?
Yes</td><td colspan="2">Has the site achieved construction completion?
Yes</td></tr>
<tr><th colspan="3">REVIEW STATUS</th></tr>
<tr><td colspan="3">Lead agency: Other Federal Agency
- U.S. Army</td></tr>
<tr><td colspan="3">Author name (Federal or State Project Manager): Rose Zeiler</td></tr>
<tr><td colspan="3">Author affiliation: Installation Manager</td></tr>
<tr><td colspan="3">Review period: November 2012 - January 2013</td></tr>
<tr><td colspan="3">Dates of SI: January 8, 2013</td></tr>
<tr><td colspan="3">Type of review: Statutory</td></tr>
<tr><td colspan="3">Review number: 1</td></tr>
<tr><td colspan="3">Triggering action date: September 7 (LHAAP-49), 2010; August 18 2010 (LHAAP004-R-01</td></tr>
<tr><td colspan="3">Due date (five years after triggering action date): August, 2015</td></tr>
</table>

Issues/Recommendations

Sites without Issues/Recommendations Identified in the Five-Year Review:
LHAAP-49; LHAAP-004-R-01

Issues and Recommendations Identified in the Five-Year Review:

Site: LHAAP-49	**Issue Category:** No Issue			
	Issue: None			
	Recommendation: None			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	U.S. Army	USEPA/State	Not Applicable

Site: LHAAP-004-R-01	**Issue Category:** No Issue			
	Issue: None			
	Recommendation: None			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	U.S. Army	USEPA/State	Not Applicable

Protectiveness Statement(s)

Site: LHAAP-49	**Protectiveness Determination:** Protective	**Addendum Due Date (if applicable):**

Protectiveness Statement:
The No Action Alternative at LHAAP-49 is protective of human health and the environment because the risk evaluation conducted determined that the site is suitable for non-residential use and compatible with anticipated future land use as a national wildlife refuge.

Site: LHAAP-004-R-01	**Protectiveness Determination:** Protective	**Addendum Due Date (if applicable):**

Protectiveness Statement:
The NFA at the former Pistol Range is protective of human health and the environment because the earlier non-time-critical removal action made the site fully compatible with the anticipated land use as a national wildlife refuge.

1 INTRODUCTION

This report completes the CERCLA Five-Year Review requirement for response action sites (interim, No Action Alternative or NFA where the site is closed to non-residential/industrial standards under 30 Texas Administrative Code (TAC) 335.559 at the LHAAP in Karnack, Texas. This report documents the status of remedial and Long-Term Monitoring (LTM) actions that have been taken, identifies issues that might impact remedy protectiveness, determines whether remedial response actions continue to be protective of human health and the environment, reviews remedial systems in place, and presents recommendations to enhance or maintain protection.

This Five-Year Review also documents the protectiveness of the remedies in place as required by CERCLA in accordance with U.S. Environmental Protection Agency (USEPA) guidance. The goals of this Five-Year Review are two-fold:

- Determine whether remedies have attained or continue to maintain protection of public health and the environment,
- Provide recommendations to address conditions where additional actions are needed to ensure long-term protection, or where documentation is lacking or limited, to verify that actions taken have eliminated or reduced risk to acceptable levels.

The U.S. Army is the lead agency responsible for completing the Five-Year Review, and is responsible to ensure that recommendations and any actions or follow-up activities identified during the Five-Year Review are addressed.

The components of the Five-Year Review are:

- Review of project reports and other applicable references/documents, such as Records of Decision (RODs), Remedial Investigations (RIs), Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFIs), RAs, Feasibility Studies (FSs), Work Plans (WPs), Operation and Maintenance (O&M) Reports, Operating Properly and Successfully (OPS) reports, risk assessments, and previous Five-Year Reviews
- Site Inspections (SIs) and interviews of U.S. Army, regulators, local agencies, and community representatives
- Review of applicable or relevant and appropriate requirements (ARAR); RAOs; RA cleanup goals; and the selected remedy based on updated information, performance monitoring data and/or promulgated standards
- Review of remedies for optimization potential that could achieve more timely, more cost efficient, or more reliable protection of human health and the environment.

The six sites with either an IRA or final remedy in place are:

- LHAAP-12 Final RA
- LHAAP-16 Early IRA
- LHAAP-18/24 IRA
- LHAAP-49 No Action

- LHAAP-04-R-01 NFA

This review is required by statute. The statutory Five-Year Review requirement was added to CERCLA as part of the Superfund Amendments and Reauthorization Act of 1986. As the lead agency at LHAAP, the U.S. Army must implement Five-Year Reviews consistent with CERCLA Section (§)121 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). CERCLA §121(c), as amended, states:

> "If the President selects a RA that results in any hazardous substances, pollutants, or contaminants remaining at the Site, the President shall review such RA no less often than each five years after the initiation of such RA to assure that human health and the environment are being protected by the RA being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such Site in accordance with [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews".

This requirement was further interpreted as presented in the NCP; §300.430(f)(4)(ii) of Title 40 of the Code of Federal Regulations (CFR), which states:

> "If a RA is selected that results in hazardous substances, pollutants, or contaminants remaining at the Site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected RA".

This is the third Five-Year Review for sites LHAAP-12, -16, and -18/24. The triggering date for this review was October 2, 2008, which was the signature date of the second Five-Year Review Report (Shaw Environmental, Inc. [Shaw] 2008). This is the first Five-Year Review for LHAAP-49 and LHAAP-04-R-01 (the Pistol Range). Because hazardous substances, pollutants, or contaminants remain at these sites at concentrations exceeding levels that allow for unlimited use and unrestricted exposure, a Five-Year Review is required.

2 LHAAP GENERAL BACKGROUND

This section presents the general background, physical characteristics, and site history for the LHAAP. Site-specific background information (i.e., history of contamination, initial response, and basis for taking RA) for each response action site undergoing detailed review is presented in Sections 3.0 through 7.0.

2.1 General LHAAP Physical Characteristics and History

The LHAAP is an inactive, government-owned, formerly contractor-operated and maintained industrial facility located in central-east Texas in the northeastern corner of Harrison County. The facility occupies approximately 1,400 of its former 8,416 acres located between State Highway 43 in Karnack, Texas, and the western shore of Caddo Lake (Figure 2-1).

Most of LHAAP consists of mixed pine-hardwood forests that cover a flat to gently rolling terrain with an average slope of 3 percent or less. Based on U.S. Geological Survey topographic maps, the western end of the site is approximately 175 feet above mean sea level (msl). The site slopes gently upward to the east until reaching approximately 180 feet msl. At the eastern end of the site, the elevation increases by approximately 10 feet. Surface water at LHAAP drains to the northeast into Caddo Lake via four drainage systems known as Goose Prairie Creek, Central Creek, Harrison Bayou, and Saunders Branch (Shaw 2008).

LHAAP was established in 1942 to produce trinitrotoluene (TNT) for use in World War II. Production of TNT was discontinued in 1945, but the facility was later used for production of pyrotechnic ammunition, rocket motor production, static firing, and elimination of rocket motors. The plant was deactivated and declared excess to the U.S. Army's needs in 1997. In December 1991, the State of Texas, USEPA, and the Department of Defense - U.S. Army LHAAP, entered into a Federal Facility Agreement (FFA) to address the contamination at LHAAP. Proposed actions are carried out under CERCLA (as implemented through the NCP) with the U.S. Army as the lead agency, in conformity with the FFA (U.S. Army 1991). The entire installation was under the control of the U.S. Army until May 5, 2004, when approximately two-thirds of the property was transferred to the U.S. Fish and Wildlife Service (USFWS). The property transfer process is continuing as responses are completed at smaller parcels of land. None of the sites addressed in this review have transferred out of U.S. Army control.

Figure 2-1 shows the locations of sites LHAAP-12, LHAAP-16, LHAAP-18/24, LHAAP-49, and the Pistol Range. Sites LHAAP-18/24 (burning ground number 3 [BG3] and the unlined evaporation pond [UEP]) are located in the southeastern portion of LHAAP, to the east of Harrison Bayou, and a portion of the site is within the 100-year flood plain. Site LHAAP-16 (Old Landfill) is located west of LHAAP-18/24 and Harrison Bayou, and encompasses approximately 16 acres in the south-central portion of LHAAP. Harrison Bayou borders LHAAP-16 to the east and southeast. The southeastern edge of the landfill is in the 100-year floodplain. LHAAP-12 is west of LHAAP-16 and on higher ground. LHAAP-12 is a grassy site surrounded by timber and encompasses approximately seven acres. The Pistol Range is located southeast of LHAAP-16, within the flood plain of Harrison Bayou. LHAAP-49 is located in the west-central portion of LHAAP and lies approximately 2.3 miles from Caddo Lake (Jacobs Engineering Group, Inc. [Jacobs] 2002a).

2.2 General LHAAP Geologic and Hydrogeologic Setting

LHAAP, including sites LHAAP-12, -16, -18/24, -49, and -004-R-01, is situated on the Wilcox Group, which is present over a large portion of the eastern half of Harrison County, Texas. The Wilcox Group consists mostly of fine- to medium-grained sands interbedded with a considerable amount of clay and seams of lignite. The Wilcox Group is underlain conformably by the predominantly calcareous clay of the Midway Group. Regional dip of the Wilcox is to the northwest into the East Texas Syncline, while the ground surface generally dips to the southeast.

The Wilcox Group has been identified by the Texas Water Development Board as the basal unit of the Cypress Aquifer, also known as the Carrizo-Wilcox Aquifer. The Cypress Aquifer is present under most of Harrison County and is comprised of, in ascending order, the Wilcox Group, the Carrizo Sand, the Reklaw Formation, and the Queen City Sand. All units are believed to be hydraulically connected. All of these units dip to the northwest into the East Texas Syncline (Shaw 2008).

The availability of ground water in Harrison County is largely dependent on the hydrologic characteristics of the units comprising the Cypress Aquifer. The Wilcox Group in the area of LHAAP yields small (less than 50 gallons per minute [gpm]) to moderate (50-500 gpm) flow rates of fresh water at wells throughout the county. As a basal unit of the Cypress Aquifer, the Wilcox is also considered as the base of fresh water in the area. The Midway Group, which does not yield usable quantities of water, tends to serve as a relatively impermeable base of the overlying water-bearing Wilcox Group. The top of the Midway Group has been encountered 75-190 feet below ground surface (bgs) under LHAAP-18/24. It is 141 feet bgs at LHAAP-12 and 225-307 feet bgs at LHAAP-16.

Groundwater at LHAAP-12, -16, and -18/24 generally occurs under unconfined conditions and the elevation fluctuates with seasonal variations in rainfall. Groundwater is encountered at depths of 11-30 feet bgs at LHAAP-18/24 (AECOM 2013, Final Quarterly Report, 4th Quarter 2012) and flows generally toward the northeast, except in the vicinity of Harrison Bayou or where influenced by the extraction system. Groundwater is encountered at depths of 11-33 feet bgs at LHAAP-16 (AECOM 2013, Final Quarterly Report, 4th Quarter 2012) and flows generally toward the east and southeast. Groundwater is encountered at depths of 19-25 feet bgs at LHAAP-12 based on 2009 through 2011 data. Generally, the flow is to the east, but flow is also observed to occur in the northeast and southeast directions (Shaw 2012). Groundwater at LHAAP-49 generally occurs under unconfined conditions, is encountered at depths of 25-35 feet bgs and flows generally toward the northeast. Groundwater elevations are observed to be impacted by long-term regional weather conditions and have fluctuated by as much as ten feet between normal and drought conditions. Based on one monitoring well drilled at the Pistol Range, groundwater is encountered at a depth of approximately 14.5 feet bgs.

2.3 General LHAAP Land and Groundwater Use

LHAAP is located near the unincorporated community of Karnack, Texas. Karnack is a rural community with a population of 2,276 people. The incorporated community of Uncertain, Texas, population of 94, is a local resort area located to the northeast of LHAAP on the edge of Caddo Lake and an access point to Caddo Lake. The industries in the surrounding area consist of agriculture, timber, oil and natural gas production, and recreation.

2.3.1 Land

LHAAP has been an industrial facility since 1942. Significant production activities continued until the facility was determined to be in excess of the U.S. Army's needs in 1997. The plant area is now inactive and approximately two-thirds of the former plant area is now controlled by the USFWS. The majority of the former footprint of LHAAP is now under the administrative control of the USFWS and is maintained and operated as the Caddo Lake Wildlife Refuge and is largely accessible to the general public. Portions of LHAAP within the refuge still requiring remediation or maintenance are surrounded by fences and warning signs (except on the border with Caddo Lake) to preclude unlimited public access. The anticipated future use of the entire facility is as a wildlife refuge.

2.3.2 Groundwater

There are three water supply wells located on LHAAP (see Figure 2-1), and they supply water to the buildings currently in use on the installation. None of these wells are used to provide drinking water. One well is located at the Fire Station (north of Goose Prairie Creek) and has been in use since 1997. A second well is located approximately one-half mile southwest of the Fire Station (directly south of LHAAP-58) and has been in use since 1999. The third well is located immediately adjacent to the former LHAAP administration building, which is currently used as the USFWS headquarters offices for the Caddo Lake Institute and the USFWS. Two additional wells previously supplied water to the installation, but these have been plugged and abandoned. The depths of the three existing wells on LHAAP are as follows (Shaw 2009b):

- Well 150 feet south-southeast of fire station: 128 feet (with a screened interval between 58-128 feet)
- Well ½ mile southwest of fire station: 195 feet
- Well at USFWS headquarters: 220 feet

Groundwater in the deep aquifer (250-430 feet bgs) near LHAAP is currently used as a drinking water source. There are currently five active water supply wells near LHAAP. One well is located in and owned by Caddo Lake State Park. The well is completed to a depth of 315 feet and has been in use since 1935. A second well owned by the Karnack Water Supply Corporation services the town of Karnack and is located approximately 2 miles southeast of town. This well is approximately 430 feet deep and has been in use since 1942. The Caddo Lake Water Supply Corporation has three wells located both north and northwest of LHAAP. These wells are identified as Caddo Lake Water Supply Corporation Wells 1, 2, and 3 and are all hydraulically upgradient of LHAAP. Because of the large distance between these wells and LHAAP, their location upgradient of LHAAP, and the completion of the wells in a zone stratigraphically lower than the depth of groundwater contamination at LHAAP, water removal from these wells is not expected to affect groundwater flow at the site, nor be impacted by LHAAP's contaminated groundwater. In addition, there are several livestock and domestic wells located in the vicinity of LHAAP with depths averaging approximately 250 feet (U.S. Army Corps of Engineers [USACE] 2010a).

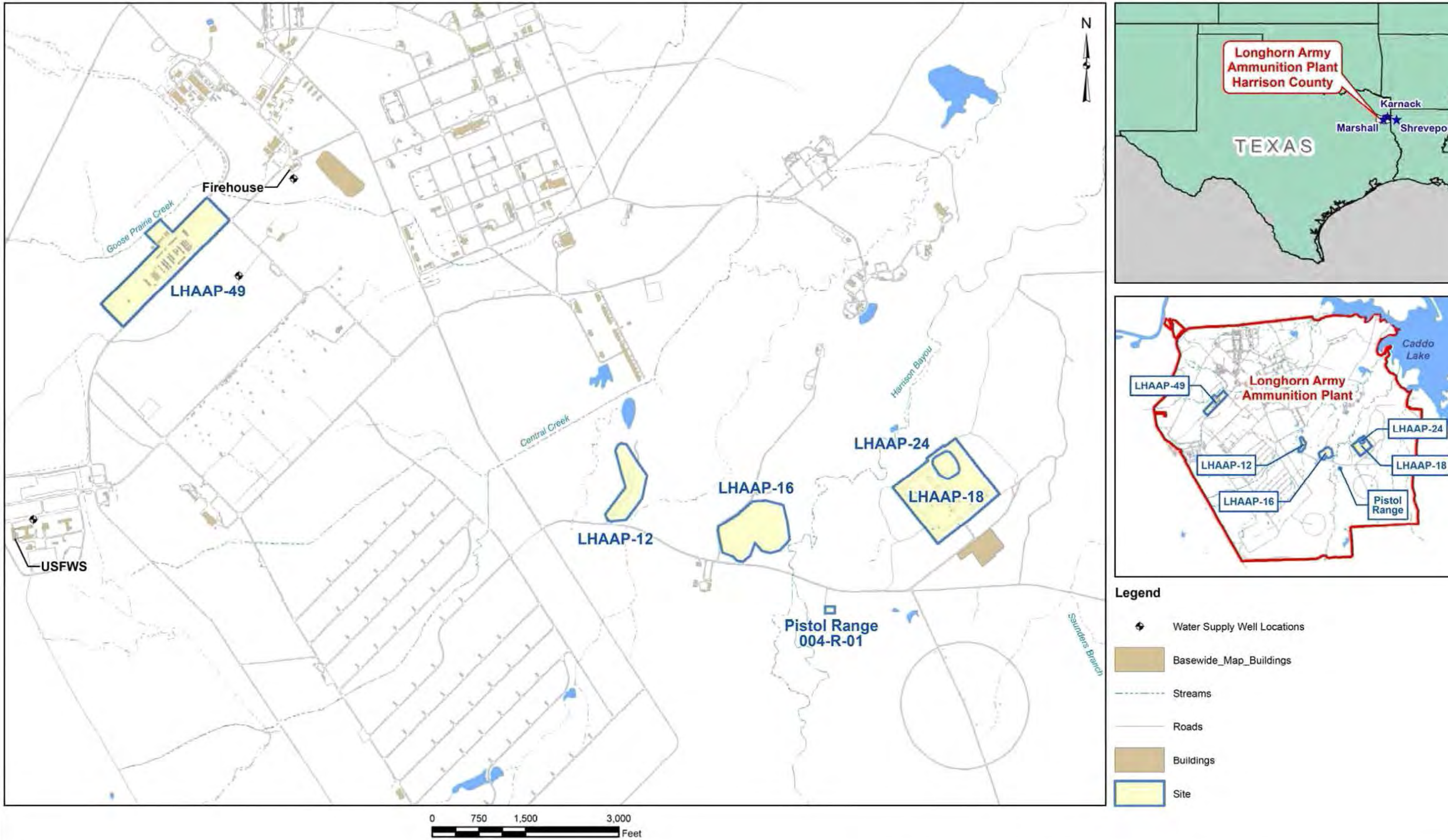


Figure 2-1
LHAAP and Site Location Map

Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2013

3 LHAAP-12

3.1 Site Chronology

Significant events relevant to site LHAAP-12 are presented in Table 3-1. In addition to the events preceding implementation of the interim and final remedies, this table provides a chronology of subsequent events continuing to the present.

Table 3-1: Chronology of Site Events for LHAAP-12[1]

Event	Date
First use of landfill	1963
Land Disposal Study No. 38-26-01014-81. U.S. Army Environmental Hygiene Agency (AEHA) installs and samples four monitoring wells at Active Landfill (Site 12)	1980
Environmental Protection Systems (EPS) installs two monitoring wells and samples all six wells	1982
Installation Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) reviewed all Sites at LHAAP and assigned numbers currently in use to identify them	April 8, 1988
LHAAP placed on NPL	August 29, 1990
LHAAP, Texas Water Commission (later Texas Natural Resource Conservation Commission [TNRCC] and now Texas Commission on Environmental Quality [TCEQ]), and USEPA enter into a CERCLA Section 120 Agreement for remedial activities at LHAAP, referred to as the FFA	December 30,1991
RCRA Part B Permit signed.	February, 1992
Phase I Field Investigation by Sverdrup installed seven additional monitoring wells and collected soil, sediment, groundwater, and surface water samples	1993
Landfill formally closed	March 1994
Phase II Field Investigation by Sverdrup installed five additional monitoring wells and collected soil, sediment, groundwater, and surface water samples	1995
Final Report-LHAAP Installation Restoration Program, Sites 12 and 16 IRA Focused FS, recommends cap design for Sites 12 and 16	March 1995
Final ROD for Early IRA at Landfill Sites 12 and 16	September 1995
Final Project Work Plans (WPs), IRA Landfill 12 and 16	June 10, 1996
IRA Construction start date	October 25, 1996
2,000 cubic yards of treated soil placed in landfill	1997
Early IRA Completed (Landfill Cap Construction completed)	October 1997
Landfill Cap LTM started	1998
Phase III Field Investigation by Sverdrup installed seven monitoring wells and collected soil, sediment, groundwater, and surface water samples	1998
Final Construction Completion Report, IRA, Landfills 12 and 16 Cap Construction, LHAAP	December 1998
Final Remedial Investigation (RI) Report for Site 12, LHAAP (Group 2 Report)	April 2001
Second Quarter Data Summary for Perchlorate Investigation	March 2001
First Five-Year Review for Sites 18 & 24 (BG3/UEP), Site 16 (Old Landfill), and Site 12 (Sanitary Landfill)	August 2002

Event	Date
Final Group 2 Sites Baseline Human Health Risk Assessment (BHHRA) and Screening Ecological Risk Assessment (Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake)	August 2002
Plant-wide perchlorate investigations are implemented, including sampling at LHAAP-12	2002
Screening-Level Ecological Risk Evaluation (SLERA) for Site 12 Soil	September 2004
Final FS, Site 12 Group 2	January 2005
Environmental Site Assessment, Phase I and II Report, Final	February 2005
Addendum to Final FS, Site 12 Group 2 (Revision 2)	March 2005
Final Proposed Plan for Landfill 12 (LHAAP-12). The proposed plan recommends final remedy consisting of MNA with LUCs that consist of cap protection provisions and groundwater restrictions	March 2005
Solutions To Environmental Problems, Inc. (STEP) issues Final Plant-wide Perchlorate Investigation for the LHAAP. For perchlorate in groundwater at LHAAP-12, the report recommends monitoring but "no further remedial measures"	April 2005
Final Remedial Design (RD) Addendum, Landfill 12 (LHAAP-12); document includes Groundwater Monitoring Plan	June 2007
Final Natural Attenuation Evaluation LHAAP-12, 35B(37), and 67	June 2007
Final OPS Demonstration Report, Landfill 12 (LHAAP-12), LHAAP	September 2007
Second Five-Year Review for LHAAP-12, LHAAP-16 and LHAAP-18/24	October 2008
Final ROD for Final Remedy at LHAAP-12	April 2006
Final RD Addendum, LHAAP-12	June 2007
Final RA Operation Summary Report, Years 1 and 2	July 2012
Final RA Operation Summary Report, Years 3 and 4	July 2012

[1]Sources: Shaw 2008, USACE 2006, Shaw 2007a, Shaw 2012a.

3.2 History of Contamination

The location of LHAAP-12, also known as Landfill 12 or the Sanitary Landfill, is shown on Figure 2-1. This site was used for disposal of nonhazardous industrial waste, including cafeteria waste, non-hazardous chemical waste, oil/diesel soaked dirt, and asbestos. Intermittent use of the landfill began in 1963. The landfill was used continuously starting in approximately 1978. As early as 1980, a U.S. Army Environmental Hygiene Agency (AEHA) land disposal study recommended changes in disposal practices due to leachate escaping from the landfill. The landfill was closed in March 1994 (Shaw 2008).

3.3 Initial Response

There were no removals or RAs at LHAAP-12 prior to the implementation of the IRA. Monitoring wells were first installed at the site in 1980. In 1990, LHAAP was placed on the National Priorities List (NPL), and in 1991, the U.S. Army, USEPA, and the Texas Water Commission (TWC) entered into a FFA designating LHAAP as a "fence to fence" site. The landfill LHAAP-12 was included in the FFA as a solid waste management unit.

Placement of industrial waste at Landfill 12 ceased in March 1994. Open trenches were covered with soil and compacted. An IRA ROD was finalized in September 1995, directing the capping of the landfill. Construction of the landfill cap began in 1996 and was completed in 1997. The site was fenced with barbed wire and warning signs were placed around the landfill (Shaw 2008). The Final ROD was issued in April 2006, documenting the final remedy consisting of Land Use Controls (LUCs) for groundwater use restrictions, maintenance and protection of the existing landfill cap, and monitored natural attenuation (MNA) (USACE 2006).

3.4 Basis for Taking Action

A landfill cap was placed over LHAAP-12 in 1998 as part of an early IRA. The stated remedial objectives for the IRA were to "minimize long-term vertical infiltration of water through the landfills; and minimize contaminant transport" (U.S. Army 1995).

While a formal risk assessment had not been completed at the time of the interim ROD, environmental investigations had revealed low to moderate levels of contaminants in the soil and groundwater at LHAAP-12. Subsequently, a Baseline Human Health Risk Assessment (BHHRA) (Jacobs 2002a) was performed for both a current trespasser and hypothetical future maintenance worker as receptors for an industrial exposure scenario. Two scenarios were considered in characterizing cancer and non-cancer risks associated with soil exposure for LHAAP-12. One scenario included soil samples collected beneath the existing landfill cap (referred to as source area). The second scenario addressed soil outside the footprint of landfill (referred to as non-source area). The resulting chemicals of potential concern (COPCs) and associated exposure point concentrations (EPCs) generated for both of the source and non-source areas were determined to be the same. As a result, only one set of cancer and non-cancer risks were calculated based on current trespasser and future maintenance worker exposure to LHAAP soil. Risks were estimated based on potential exposure pathways of direct skin contact with contaminated soil, incidental ingestion of soil, inhalation of contaminated chemical vapors and soil particles, ingestion of groundwater, and dermal contact with both soil and groundwater. The results are summarized below:

- Soil: Current trespasser and future maintenance worker exposure generated acceptable cancer risks and non-cancer hazards. For all soil scenarios, individual and cumulative cancer risks were below 10^{-6}, and non-cancer hazards (individual and cumulative) were less than 1.
- Groundwater: Future maintenance worker exposure to the on-site groundwater generated an unacceptable non-cancer hazard of 5.8. The non-cancer hazard is primarily associated with exposure to trichloroethene (TCE) by the ingestion and dermal contact pathways. Calculated hazard quotient values for exposure to organic compounds bis(2-ethylhexyl)phthalate, cis-1,2-dichloroethene (DCE) and vinyl chloride (VC) did not sum to 1. The estimated cancer risk associated with potential exposure of the future maintenance worker to all chemicals by all exposure pathways is 1.3×10^{-4}.

In addition to the baseline risk assessment, a Screening-Level Ecological Risk Evaluation (SLERA) (Shaw 2004) was completed in 2004. This assessment of the non-source area showed that the site posed no risk to a potential residential receptor. The screening level ecological risk assessment indicated low potential for ecological risks at LHAAP-12. Multiple lines of evidence were used in this assessment, such as comparison of maximum detected concentrations to background levels, and other considerations including the magnitude by which the screening benchmark was exceeded, how frequently the chemical was detected, etc.

The Final ROD was issued in April 2006. Based on the Final ROD (USACE 2006), the primary contaminant of concern (COC) for LHAAP groundwater is TCE due to its significant contribution to the total risk. Although perchlorate did not present an unacceptable risk or hazard, it was considered a COC in the FS due to its exceedance of the Texas Natural Resources Conservation Committee (TNRCC) perchlorate Interim Action Limit of 4 µg/Lin historical samples (Shaw 2005).

However, during the perchlorate sampling event, completed by Solutions To Environmental Problems, Inc. (STEP) in September 2002 (STEP 2005), and in three subsequent rounds by the USACE (USACE and ALL Consulting 2006), perchlorate was not detected in LHAAP-12 monitoring wells. The results indicated that perchlorate was not present in groundwater at LHAAP-12 (USACE and ALL Consulting 2006).

The Conceptual Site Model (CSM) for LHAAP-12 is presented in the Final ROD (USACE 2006). The model presents the role of the landfill cap constructed in the IRA and specifies the potential exposure pathways that were cut off by the landfill cap. The multilayer cap reduces the potential for vertical migration of contaminants via rainfall infiltration through the landfill. The cap has perimeter berms and drainage swales to control surface drainage. Groundwater contamination is of concern at LHAAP-12. Groundwater contamination was probably caused by the migration of contaminants, via rainwater infiltration, from the landfill waste to groundwater prior to capping the landfill. Historic releases of contamination from the landfill have caused slightly elevated concentrations of residual contaminants (e.g., metals), but the sediment risk and hazards are within acceptable limits. Contamination in drainage water is minor and does not exceed background concentrations present in surface water from Central Creek that is entering LHAAP. TCE in groundwater migrated as a small, narrow plume approximately 250 feet east of the northeast corner of the landfill cap boundary with contaminants found in only two monitoring wells. The potential exists for groundwater contaminants to pose an unacceptable human health risk to an industrial worker and to discharge to nearby surface water bodies, which could ultimately affect Caddo Lake (USACE 2006).

3.5 Remedial Actions

3.5.1 Regulatory Basis for Action

The IRA ROD for LHAAP-12 established an IRA to mitigate potential risks posed by buried source material at the site. The U.S. Army issued the IRA ROD on September 27, 1995.

The Final ROD was issued by the U.S. Army who is the lead agency for the installation. The USEPA (Region 6) and the TCEQ are the regulatory agencies providing technical support, project review and comment, and oversight of the U.S. Army cleanup program. The USEPA and TCEQ concurred with the selected remedy consisting of LUCs and MNA. The remedy selection was based on the Administrative Record file for this site, including the RI and BHHRA (Jacobs 2002a), FS (Shaw 2005a), the Addendum to the FS (Shaw 2005b), the Proposed Plan (U.S. Army 2005), and other related documents contained in the Administrative Record file for LHAAP-12. The remedy was chosen in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), and, to the extent practicable, the NCP.

3.5.2 Remedial Action Objectives

The RAOs (USACE 2006) developed for LHAAP-12 include:

- Protection of human health by preventing human exposure to TCE-contaminated groundwater;
- Protection of human health and the environment by reducing the leaching and migration of landfill hazardous substances into the groundwater; and
- Protection of human health and the environment by preventing TCE-contaminated groundwater from migrating into nearby surface water.

The IRA RAO to minimize the infiltration of water through the landfill and contaminant transport was achieved with the construction of a landfill cap and institution of LUCs for the protection of the cap.

The primary COC for LHAAP-12 groundwater is TCE due to its significant contribution to the total risks (USAF 2006). The contaminants, cis-DCE, and VC are the degradation products of TCE. The objective of groundwater monitoring is to ensure that the Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) are achieved for groundwater contaminants TCE, cis-1,2-DCE, and VC. The MCLs for TCE, cis-1,2 DCE and VC are 5, 70 and 2 μg/L respectively (Shaw 2007b). The MCLs are based on SDWA which has been identified as a chemical-specific ARAR for groundwater at LHAAP-12.

3.5.3 Remedy Description

A landfill cap was installed in 1998 as part of the early IRA to mitigate potential risks posed by buried source material at the site. The cap includes the following components:

- Foundation soil layer
- Low permeability sodium bentonite geocomposite
- Geosynthetic membrane liner
- Final soil cover with adequate slopes and vegetation
- Perimeter berms and drainage swales to control surface water runoff.

The IRA ROD (USACE 1995) included LUCs such as warning signage, use restrictions, regular inspections, maintenance, and repair of the cap.

The final remedy for LHAAP-12 (USACE 2006) is LUCs (existing and new) in conjunction with MNA. The LUCS at LHAAP-12 include:

- Maintenance of the integrity of the landfill cap, including at a minimum, repairs to desiccation cracks, erosion, or gullying upon observance
- Maintenance of vegetative cover on the landfill cap including regular mowing
- Maintenance of signage around the landfill cap
- Prohibition of any activities that would affect the integrity of cap
- Prohibition of any activities that would cause exposure to the contaminated groundwater.

Due to the potential for TCE-contaminated groundwater to migrate, MNA is included as a component in the final remedy. Groundwater monitoring is conducted to monitor the effectiveness of MNA in reducing contaminant concentrations over time. Monitoring is also conducted to evaluate the effectiveness of the existing cap and to assure that the plume does not migrate to nearby surface water at levels that may present an unacceptable risk to human health and the environment.

3.5.4 Remedy Implementation

Consistent with the IRA ROD and approved design, a multilayer cap has been constructed overlying the source area of LHAAP-12. During cap construction, monitoring wells within the landfill limit were plugged and abandoned. Upon construction of the cap, administrative LUCs have been implemented to restrict access and usage to maintain the integrity of the landfill cap. Periodic inspections of the landfill cap have been performed since June 2000, shortly after the official date for cap construction completion (August 31, 1999) (Shaw 2007).

The final remedy is currently in the operating phase in accordance with the Remedial Design (RD) completed in June 2007. The LUC and maintenance area associated with the landfill cap is approximately seven acres and comprises the landfill cap, extending to the surrounding fence. The LUC area associated with the groundwater use restriction extends beyond the cap area encompassing approximately 46 acres in a downgradient direction toward Central Creek (see Figure 3-1). As part of LUCs, specific measures were implemented to restrict access and limit exposure to contaminated groundwater. These measures include incorporating the LUCs in the Site-wide LUC Management Plan, annual physical inspections, and cap maintenance. Until LHAAP-12 is transferred, the U.S. Army or its representatives will be responsible for LUC implementation, maintenance, inspection, reporting, and enforcement. The U.S. Army may, as a condition of property transfer, require the transferee to assume responsibility for various implementation actions, but will retain responsibility for remedy integrity. The LUCs will remain in effect until the U.S. Army, TCEQ and USEPA agree that contaminant concentrations at the site have been reduced to levels that allow for unlimited use and unrestricted exposure. In general, the inspection activities at LHAAP-12 consist of the following:

- Visual inspection of the cap and the vegetative cover;
- Visual inspection of monitoring wells and signage;
- Visual inspection to ensure that no water wells have been installed and land use/groundwater use remain consistent with that mandated by the Final ROD;
- Visual inspection of site conditions and interviews with relevant personnel, which are used to evaluate whether prohibited activities occurred at the site;
- Completion of visual inspection activities by walking through the site. During the inspection, field notes, a checklist, and a photographic log are maintained to document observed conditions.

The groundwater monitoring network consists of three on-site monitoring wells (12WW20, 12WW21, and 12WW24) and two downgradient compliance wells (12WW22 and 12WW23). These wells are screened in the shallow groundwater zone. Groundwater monitoring and MNA evaluation are being conducted following the Final RD Addendum, Landfill 12 (Shaw 2007b).

Sampling was initiated in September 2007. Samples were collected from the five wells on a quarterly basis for the first two years, and annually thereafter. For the four quarterly sampling events of Year 1, groundwater samples collected from select wells were also analyzed for MNA parameters. The results of MNA evaluation is presented in the Remedial Action Operation Summary Report (Shaw 2012a). The MNA evaluation concluded that TCE degradation was occurring via anaerobic reductive dechlorination. This was supported by historical volatile organic compound (VOC) trend analysis and qualitative assessment of geochemical indicators. The low ORP and nitrate levels were indicative of conditions conducive to anaerobic reductive dechlorination process. The compliance wells are monitored to verify that VOCs do not discharge to surface water bodies at levels exceeding the ARARs. The groundwater monitoring data, including historic data, indicates that the plume is small and stable and not migrating to surface water. Groundwater elevation was measured during each sampling event. Bi-annual reports are prepared to document the monitoring program (Shaw 2007b).

Future use of the LHAAP-12 parcel is intended as a national wildlife refuge consistent with nonresidential use. Upon transfer to the USFWS, the LHAAP-12 area, including the LUC restricted areas, the future use will be used solely for the purpose of a national wildlife refuge consistent with industrial or recreational activities and not for residential purposes.

3.6 Compliance Monitoring

Compliance monitoring at LHAAP-12 consists of annual SIs, annual groundwater monitoring, and Five-Year Reviews. The U.S. Army inspects all land use restrictions and controls for LHAAP-12 specified in the ROD on an annual or more frequent basis (such as in conjunction with mowing which is completed two to three times per year) to determine the effectiveness and compliance with these restrictions and controls. The inspections include determining any violations of the LUCs, as well as indicators of cap degradation, maintenance issues, trespass, and incompatible use. Annual inspection forms are contained in Remedial Action Operations (RAO) Summary Reports for years 2008, 2009, 2010, and 2011 published biannually during the review period. The RAO Summary Report (Shaw 2012a) included SI findings (2006 through 2012) and groundwater monitoring data from 2008 through 2011. Subsequent inspection, sampling, and repairs completed in 2012 will be documented in a forthcoming RAO Summary Report to be published in 2014. The U.S. Army conducts groundwater monitoring to evaluate effectiveness of the cap, track MNA progress, and also to ensure that contaminants do not discharge to nearby surface water bodies at concentrations exceeding their respective ARARs. The need to continue LUCs to restrict groundwater and MNA is reviewed every five years as part of this review.

Because contaminants remain at LHAAP-12 above levels that allow for unlimited use and unrestricted exposure, a Five-Year Review is conducted every five years to ensure protection of human health and the environment under CERCLA §121(c), U.S. Code (U.S.C.) Title 42 §9621(c).

Although there is no current or anticipated future use of the groundwater as drinking water, the U.S. Army recognizes the USEPA's expectation that contaminated groundwater will be restored to its beneficial uses where practicable, per 40 C.F.R § 300.430(a)(1)(iii)(F). Therefore, it is the U.S. Army's expectation to restore the contaminated zone at LHAAP-12.

3.7 Systems Operations and Maintenance

Except for monitoring, LHAAP-12 does not have active remedial systems. As part of the landfill inspections, wells are visually inspected during sampling activities and mowing, weeding, and brush clearing activities are completed several times per year as needed. Damage or irregularities to the wellheads are reported at the time they are identified and recorded in field notes or on sampling forms, and repaired or scheduled for repair when needed. Groundwater sampling is completed annually. Specific results from each inspection are documented in a Remedial Action Operations Report for the site. Additional system performance data are compiled and published in the LHAAP-18/24 groundwater treatment plant (GWTP) monthly and quarterly reports which were completed throughout the review period.

3.7.1 Treatment or Other System Processes

The O&M of LHAAP-12 has been carried out by different contractors since the maintenance of the landfill began in 1998. USACE currently contracts with AECOM Technical Services, Inc. (AECOM) to provide O&M activities for LHAAP-12. From January 2006 to July 2012, Shaw performed O&M. From June 2000 to December 2005, Complete Environmental Service, Inc. (CES) performed O&M. Prior to June 2000, Radian International, LLC. (Radian) performed the O&M activities. The primary O&M activities are as follows:

- Maintain the signs and mow the associated areas at LHAAP-12
- Inspect the cap and perform repairs as required
- Monitor the performance of natural attenuation at LHAAP-12
- Maintain LUCs at LHAAP-12.
- As part of routine maintenance, physical inspection of cap was performed from 2006 to 2012. Other than the presence of a few tree seedlings and erosion observed during June 2008 and 2009 inspection, some minor erosion/subsidence was identified and repaired with the addition of soil and vegetation in 2012.

  Wells are visually inspected during sampling activities and when mowing, weeding, and brush clearing activities are completed. Damage or irregularities to the wellheads are reported at the time they are identified and recorded in field notes or on sampling forms, and were repaired when needed.

3.7.2 Operations and Maintenance Costs

The approximate costs for O&M and LTM activities at LHAAP-12, LHAAP-16, and LHAAP-18/24 are not subdivided into individual site estimates, thus assessment of individual site cost performance is not possible. The original O&M total cost estimate for LHAAP-12 and LHAAP-16, and cost estimate for LHAAP-12 RAO LTM, was $75,000/year (USACE 1995a). The original O&M total cost estimate for LHAAP-18/24 was $400,000/year (USACE 1995b). The combined approximate actual O&M and LTM cost estimates for sites LHAAP-12, LHAAP-16 and LHAAP-18/24 are presented in Table 3-2, including monitoring well maintenance activities.

Table 3-2: O&M and LTM Costs for LHAAP-12, LHAAP-16 and LHAAP-18/24

Calendar Year	O&M Approximate Actual Costs	LTM Approximate Actual Costs
2008	$416,328	$247,127
2009	$354,210	$112,240
2010	$354,205	$102,188
2011	$354,205	$38,628
2012	$1,118,889	$108,666

From 2007 through 2011 the annual estimates are stable or decreasing. The increased costs for the seven months of 2012 are due to deferred maintenance and essential upgrades to equipment and are not indicative of any effects on protectiveness with 2012 repairs and replacements enhancing effectiveness.

3.8 Progress Since the Last Five-Year Review

This section provides a record of progress since the completion of the second five-year in 2008. The final remedy has been implemented at LHAAP-12; the site is currently in the RAO phase. RAO Summary Reports for the first four years were completed in July 2012 (Shaw 2012a).

3.8.1 Previous Protectiveness Statements and Recommended Actions

The protectiveness statements from the previous Five-Year Reviews (CES 2002; Shaw 2008) are presented in Table 3-3. Recommendations/follow-up actions associated with these statements were also developed in the earlier reviews. The status of those actions was evaluated as part of the current review, and the results are provided in Table 3-4.

Table 3-3: Protectiveness Statements from Previous Reviews

First Five Year Review (CES 2002)
The Early IRA at Site 12 is expected to be protective of human health and the environment, and in the interim, exposure pathways that could result in unacceptable risks are being controlled. The early IRA at Site 12 is expected to reduce the potential for vertical infiltration of water through the landfills and to minimize contaminant transport. The assessment of this Five-Year Review found that the remedy was constructed in accordance with the requirements of the ROD for Site 12. Although the cap is protective of the environment and human health by reducing the amount of water moving through the source material, the effectiveness of the cap needs to be further evaluated. Groundwater monitoring has not been conducted frequently enough to establish seasonal groundwater contours or contaminant trends. In addition, non-source area soil that contains contaminants is not protected by the cap from infiltration of water and may be a cause of concern. The risk assessment for the site also needs to be completed. As an Early IRA, the cap was not intended to be final solution. However, pending the outcome of the risk assessment and groundwater monitoring, the cap may be the final solution.
Second Five Year Review (Shaw 2008)
The Final RA at LHAAP-12 currently protects human health and the environment by reducing the leaching and migration of hazardous substances, preventing contaminated groundwater from migrating to surface water, and preventing human exposure to contaminated groundwater. The Final ROD for LHAAP-12 has been signed, and the RD is complete. The site is now in the RAO phase. The cap, installed as the IRA, is now part of the final remedy. The final remedy also includes MNA with LUCs that consist of cap protection provisions and groundwater restrictions. This Five-Year Review found that the cap was constructed in accordance with the requirements of the IRA ROD for LHAAP-12 and that the cap is being maintained sufficiently to satisfy its objective of minimizing infiltration. O&M procedures are addressed via the RD documentation and recommendations for documented annual inspections for the landfill were included. LUCs have been implemented under the Final ROD both to protect the cap and to prevent human exposure to contaminated groundwater. The current OPS evaluation has concluded that the cap and MNA together result in a reduction of the leaching and migration of landfill hazardous substances into the groundwater.

Table 3-4: Recommendations for LHAAP-12 from Previous Reviews

Issue	Recommendation/Follow-up Action	Party Responsible	Oversight Agency	Milestone Date	Affects Current Protectiveness?	Affects Future Protectiveness?	Path Forward/Status	Completion Date
Status of Recommended Actions from First Five-Year Review								
Groundwater monitoring not conducted regularly	Sample monitoring wells on a regular basis	USACE	State/USEPA	5/30/02	No	Yes	USACE performed limited sampling. Regular sampling was initiated as part of RAO.	2003/2004 2008
Need O&M Plan	Write and implement an O & M Plan	USACE	State/USEPA	5/30/2002	No	Yes	O&M requirements have been addressed in the RD Addendum and the LUCs Management Plan, and an O&M plan is currently under development.	June 2006 (issue date of RD Addendum)
Non source soils not protected by cap	Investigate and determine if action is necessary	USACE	State/USEPA	5/30/2002	No	Yes	Risk assessment completed as part of Addendum to Final FS	March 2005 (issue date of the Addendum)
Status of Recommended Actions from Second Five-Year Review								
Some minor erosion and unwanted vegetation on landfill caps	Repair erosion and remove small pine trees	U.S Army	State/USEPA	12/31/08	No	Yes	The pine trees were sprayed with herbicide in December 2008. The caps were inspected in March 2009, and the decision was made to spray again. That spraying occurred in June and July 2009. Erosion locations are being observed during each inspection. Areas that erode further will be repaired with clean fill and seeded.	July 2009. Erosion and cap vegetation will continue to be evaluated in semi-annual inspections.

[a] Source: LUC Inspection and Maintenance Log (Shaw 2008)

3.8.2 Status of Ongoing Activities

In accordance with the 1995 ROD (USACE 1995), LHAAP-12 was capped in 1997. The combination of the landfill cap with MNA and LUCs (i.e., the final remedy described in the 2006 ROD for LHAAP-12), has been evaluated in the *Final Operating Properly and Successfully (OPS) Demonstration Report, Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plant, Karnack, Texas* (Shaw 2007a). The MNA evaluation was based on groundwater analytical data for TCE, cis-1,2-DCE and VC from two snapshots in time (in 1998, shortly after completion of the cap construction fieldwork, and in December 2006 during the MNA study). As noted in that document:

> *"The LHAAP-12 landfill cap and groundwater MNA are operating properly because both RA components have been constructed as designed, and are operating in accordance with the approved design. The cap is also functioning successfully, in that exposure to the buried waste is controlled and reduction of the leaching and migration of landfill hazardous substances into the groundwater is evident. LUCs are reliable and will remain in place to provide future protection of human health and the environment. Additionally, a monitoring program for the cap and the groundwater MNA is being performed and will continue in perpetuity unless otherwise agreed upon between the Army and its transferee (the USFWS), USEPA Region 6 and the TCEQ."*

From 1998 to 2004, a BHHRA, a SLERA, and a residential risk screening were conducted (Jacobs 2002a; Shaw 2004 and 2005b). It was determined that the groundwater posed unacceptable risks for a hypothetical future maintenance worker. The final FS was issued (Shaw 2005a and b). A Proposed Plan (U.S. Army 2005) facilitating public involvement in the selection of the final remedy for LHAAP-12 was issued in March 2005. The ROD for the final remedy was issued in April 2006. The final remedy at LHAAP-12 consists of LUCs for groundwater use restrictions, maintenance of the existing landfill cap and LUCs for protection of the existing landfill cap, and MNA. This remedy is consistent with the intended future use of the site as a part of a wildlife refuge.

The U.S. Army provided details of the LUCs implementation actions in the RD Addendum, which was approved by the regulatory agencies and issued as final on June 21, 2007 (Shaw 2007b). Maintenance of the LUCs is addressed within the *Comprehensive LUC Management Plan* (released in September 2007). The RD Addendum (Shaw 2007b) stipulated SIs to be conducted annually to ensure compliance with the LUC requirements and groundwater sampling to monitor the effectiveness of MNA in reducing contaminant concentrations over time.

SIs have been occurring annually since 2000. The integrity of the landfill cap was observed to remain intact during these inspections. Slight erosion of the landfill cap appeared to be an issue from 2006 through 2009. The 2010 through 2012 inspections indicated that no repairs were needed at that time to maintain the integrity of the cap. No desiccation cracks, gullying, or erosional effects have been observed and no seedlings were observed growing on the landfill cover. Periodic mowing is conducted during the growing season. Cap integrity remains intact as observed during these activities as well as noted during the annual physical inspections. No drinking water wells have been installed at LHAAP-12; signage at LHAAP-12 remains intact and legible. No change in land or groundwater use has occurred at the site and the use of the site is consistent with that mandated by the ROD (USACE 2006).

Inspections, mowing, fence and gate repair, and signage replacement has been completed as needed throughout the review period, and additional soil and vegetative cover have been identified and addressed.

In accordance with the Groundwater Sampling Plan included in the RD Addendum (Shaw 2007b), an on-ongoing groundwater sampling program including monitoring wells 12WW20, 12WW21, and 12WW24, and two compliance monitoring wells, 12WW22 and 12WW23 is currently in place since 2007. Well 12WW24 was added in an addendum to the RD in order to increase the effectiveness of the MNA program. Four of these monitoring wells were also abandoned and replaced with new polyvinyl chloride (PVC) wells due to suspicion that the original stainless steel was corroded and impacting results. All of these wells were sampled and analyzed for VOCs and MNA parameters every quarter for the first two years (2007/2008, 2008/2009). Subsequently, samples are collected annually for VOCs. Monitoring well 12WW24 was found dry during the December 2012 sampling event.

3.9 Five-Year Review Component

3.9.1 Administrative Review

The LHAAP Five-Year Review team was led by Dave Wacker (AECOM), who serves as AECOM Project Manager for LHAAP. The overall team was composed of the members listed in Table 3-5.

Table 3-5: Five-Year Review Team

AECOM	Project Manager: Dave Wacker. Senior Engineer: Naseem Hasan, P.E. Chemist: Celia Flores Senior Review: Anne Lewis-Russ, Ph.D. Senior Risk Assessor: Rotha Randall Senior ARAR Assessor: Ruth Hammervold
LHAAP	Site Manager: Rose Zeiler, Ph.D.
USACE	Project Engineer: Aaron Williams, P.E.
TCEQ	Remedial Project Manager: April Palmie
USEPA	Remedial Project Manager, Rich Mayer, P.G.
USFWS	Paul Bruckwicki
Restoration Advisory Board (RAB)	RAB Co-Chair: Paul Fortune RAB Co Chair: Judith Johnson RAB Member: Richard LeTourneau

The review included the following activities:

- Review of relevant documents
- Data review
- SIs

- Local interviews
- Community involvement.

The Five-Year Review was conducted in accordance with the USEPA Comprehensive Five-Year Review Guidance (USEPA 2001).

3.9.2 Community Involvement

Community notification was accomplished via interviews and publishing a notice in the local paper. The public notice was published in the Marshall News Messenger on December 14, 2012. When the Five-Year Review report is finalized, another notice will be published to indicate that the report will be available to the public at the Marshall Public Library (300 South Alamo Boulevard in Marshall, Texas 75670). The public notice is presented in Appendix B.

3.9.3 Document Review

This Five-Year Review consists of a review of relevant documents including interim and Final RODs, previous Five-Year Reviews, RI, FS, risk assessments, WPs, RDs, construction and RA operation summary reports, OPS report, LUC inspection logs and monitoring data. The list of documents reviewed is provided in Appendix D1.

3.9.4 Data Review

The data review portion of this Five-Year Review focuses on groundwater monitoring data that may provide information on the combined performance of the cap and MNA remedy for the groundwater.

3.9.4.1 Potentiometric Surface

Figures D2-1 through D2-4 (presented in Appendix D2) display contours representing the shallow groundwater surface in the area where the TCE plume is present. The groundwater gradients contoured from 2010 and 2011 data trend towards the east (Figure D2-1) indicating a downgradient flow direction from 12WW24 to the east (Shaw 2012a). Historical data from spring 2003, spring 2004, and winter 2004 (Figures D2-2, D2-3 and D2-4) show that the groundwater gradient can vary in this part of the site. Generally, the flow is to the east, but flow is also observed to occur in the northeast and southeast directions. Changes in the groundwater flow direction can occur both seasonally and in the longer-term (Shaw 2012a) and is influenced by the orientation and thicknesses of sand bodies.

3.9.4.2 Contaminants

Groundwater monitoring is being performed at LHAAP-12 in accordance with the RD (Shaw 2007b). Samples are collected from five monitoring wells (12WW20, 12WW21, 12WW22, 12WW23, and 12WW24) and analyzed for VOCs. Figure 3-2 (also presented as Figure D3-1 in Appendix D3) presents the TCE plume based on 2009 data (Shaw 2012a). Monitoring well 12WW24 is the only well that lies within the plume. Data from 2006 through 2012 are presented in Table 3-6. TCE and its degradation products were detected only in 12WW20 and 12WW24. TCE, cis-1,2-DCE, trans-1,2-DCE, and VC remain below their respective cleanup levels at 12WW20. Historical and current TCE data indicate a decreasing trend in concentrations over time at 12WW24 (Figure D4-1 presented in Appendix D4). This could be due to either of the

MNA processes such as reductive dechlorination or dispersion. A comparative analysis of TCE concentrations in conjunction with those of its daughter products does not depict any distinct increasing trends of daughter products with reducing TCE concentrations at 12WW24. This could be due to possible aerobic degradation of DCE/VC at low dissolved oxygen concentrations or abiotic degradation of DCE/VC in the presence of iron/manganese. The presence of reductive dechlorination daughter products (cis-1,2-DCE, trans-1,2-DCE, and VC) at 12WW20 and 12WW24 indicate that reductive dechlorination is effective in the vicinity of 12WW24 and for the TCE plume (Table 3-7).

It is to be noted that the MNA evaluation was based on VOC data from 12WW24 which was found dry during December 2012 sampling event. Therefore, a well should be installed in close proximity to 12WW24 to obtain VOC data during low flow period in winter months. It should be evaluated whether additional wells within the plume and its boundary would better enable a determination if the plume is stable or shrinking. Water level measurements from existing and newly installed MNA network wells as well as existing non-network wells will also allow better assessment of possible seasonal effects, if any on VOC concentrations in groundwater.

Table 3-6: TCE Concentrations (µg/L) at Monitoring Wells at LHAAP-12[1]

Sampling Date	Monitoring Wells				
	12WW20	12WW21	12WW22	12WW23	12WW24
Dec 2006	0.713	ND(1)	ND(1)	ND(1)	404
Sept 2007	1.34	ND(1)	ND(1)	ND(1)	272
Dec 2007	1.19	ND(1)	ND(1)	ND(1)	313
Mar 2008	0.999J	ND(0.25)	ND(0.25)	ND(0.25)	301
Jun 2008	1.04	ND(0.25)	ND(0.25)	ND(0.25)	237
Sept 2008	0.985	ND(0.25)	ND(0.25)	ND(0.25)	185
Feb 2009	1.18	ND(0.25)	ND(0.25)	ND(0.25)	334
Apr 2009	0.997	ND(0.25)	ND(0.25)	ND(0.25)	197
Jul 2009	0.931	ND(0.25)	ND(0.25)	ND(0.25)	204
Jun 2010	0.353J	ND(0.25)	ND(0.25)	ND(0.25)	145
Jun 2011	0.263J	ND(0.25)	ND(0.25)	ND(0.25)	147
Dec 2012	0.5J	0.582J	ND(0.5)	ND(0.5)	Dry Well

[1] Source: AECOM Project database
Notes:
µg/L micrograms per liter
ND not detected; values within parentheses denote detection limits

Table 3-7: Concentrations (µg/L) of Degradation Products at 12WW24[1]

Sampling Date	Cis-1,2-DCE	Trans-1,2-DCE	VC
Sept 2007	82.5	ND(0.5)	2.33
Sept 2007	82.5	ND(0.5)	2.33
Dec 2006	113	0.425	5.35
Dec 2007	103	0.404J	3.26
Mar 2008	89.3	ND(0.5)	3.84
Jun 2008	59.0	ND(0.5)	1.75
Sept 2008	54.3	ND(0.5)	1.45J
Feb 2009	96.2	ND(0.5)	3.6
Apr 2009	56.5	1.12	1.46
Jul 2009	50.4	ND(0.5)	0.681J
Jun 2010	27.1	ND(0.25)	0.577
Jun2011	25.3	0.684	0.358
Dec 2012	Dry Well	Dry Well	Dry Well

[1] Source: AECOM Project database
Notes:
DCE dichloroethene
ND not detected; values within parenthesis denotes detection limits
µg/L micrograms per liter
VC vinyl chloride

3.9.5 Site Inspection

Representatives of the USEPA, the TCEQ, U.S. Army, and AECOM carried out an inspection at LHAAP-12 on January 8, 2013. The purpose of the inspection was to objectively assess the operations and effectiveness of the remedy (landfill cap and LUCs) implemented at this site. During the site visit, a Five-Year Review SI checklist was completed to document the status of LHAAP-12 (Appendix D5). Weather was clear and the temperature ranged between high 50s and low 60s degrees Fahrenheit (°F) at the time of the SI. Photographs of the site visit are presented in Appendix D6.

The summary of SI findings and recommendations is as follows. LHAAP-12 is surrounded by warning signs posted along the fence line surrounding the cap. The vegetative cover was observed to be in good condition and well-maintained through routine mowing, except for a few spots affected by subsidence and minor erosion. Subsidence, as deep as 1.5 feet, was observed to be present in several locations. These spots were flagged for backfilling by AECOM and have subsequently been repaired with the addition of soil and vegetation. Signage remains in good condition and the fencing is intact except along the eastern edge of the landfill cap which requires repair. Well-head lock conditions appeared to be deteriorated or damaged during the site visit but were subsequently replaced in June 2013. Monitoring well identification tag replacement as well as painting/re-labeling, as warranted for wells outside the current monitoring network is planned for fall 2013. Minor surface erosion and signs of burrowing animals were observed on the eastern edge of the cap. No excessive cracking or desiccation was observed for the landfill cap. No change in land or groundwater use was observed at the site and the use of the site is consistent with that mandated by the Final ROD (USACE 2006). Onsite documents and records were verified for completeness. These included, but were not limited to, O&M manuals, as-built drawings, and maintenance logs, site-specific Health and Safety Plan (HASP), SOPs from the Installation Wide WP, daily access/security logs, and compliance records including annual inspection forms. All the documents listed above are up to date and are in satisfactory condition. No significant issues were identified regarding the cap condition or maintenance, signs, and site use

3.9.6 Interview Summary

Interview Summary forms are presented in Appendix I.

3.10 Technical Assessment

3.10.1 Question A: Is the remedy functioning as intended by the decision documents?

Answer: Yes

Element	Assessment
RA Performance	The final remedy at LHAAP-12 includes LUCs and MNA combined with capping implemented as an Early IRA. The cap is providing long-term protection by minimizing the infiltration of water into the landfill. LUCs consist of cap protection provisions and groundwater use restrictions. LUCs are functioning to mitigate potential risks to human health and the environment by restricting access to the contaminated media. Of the five wells designed to evaluate MNA, TCE was observed consistently above the cleanup criteria in only one well, 12WW24, until June 2011. TCE concentrations in 12WW24 have decreased over time (400 µg/L in 2006 to 147 µg/L in June 2011) as a result of natural attenuation. The well was dry in December 2012, and should be checked periodically in order to take samples when water is present. MNA appears to be effective at LHAAP-12 as indicated by the presence of reductive dechlorination daughter products.
System Operations/O&M	The cap is functioning as designed and needed only routine maintenance. The cap is maintained and inspected in accordance with the RCRA requirements. The RD (Shaw 2007b) defines O&M requirements for LHAAP-12. Five wells are inspected and sampled annually and are maintained or repaired when issues are identified.
Cost of Systems Operations/O&M	The O&M cost for LHAAP-12 is combined with that of LHAAP-16 and LHAAP-18/24. Based on 2007-2011 data, the incurred costs for these three sites are stable or decreasing compared to the estimated cost except for LHAAP-18/24 which requires periodic recapitalization or optimization which may increase costs periodically.
Opportunities for Optimization	None
Early Indicator of Potential Remedy Failure	Some minor erosion issues were observed in the past but these have been adequately addressed. During the January 2013 SI, minor landfill cap subsidence, minor erosion, and minor damaged well-head locks were observed. Well-head locks were replaced in June 2013. Subsidence/erosion was also addressed by backfilling with soil and seeding in June 2013. These issues identified were addressed through maintenance/replacement. No indicators of potential failure were observed during this Five-Year Review.

Element	Assessment
Implementation of Institutional Controls and Other Measures	The January 2013 SI at LHAAP-12 indicated that since the last inspection signage was observed to be in good condition. Part of the fencing may need replacement since the warning signage is attached to the fencing. The access road was observed to be in good condition. The site condition is still consistent with that mandated by the Final ROD. There was no evidence of changes in land use such as installation of drinking water wells. The property is under the jurisdiction of the U.S. Army pending transfer. The OPS document for LHAAP-12, which was not a statutory requirement, was issued in September 2007.

3.10.2 Question B: Are the assumptions used at the time of remedy selection still valid?

Answer: Yes

Element	Assessment
Changes in Standards and to be considered (TBC) Requirements	Regulatory requirements were considered in the selection of the final remedy. The ARARs developed for the LHAAP-12, Landfill 12, and included in the ROD (USACE 2006) are evaluated in Appendix C. The ROD for LHAAP-12 identified specific ARARs pertaining to the site. The types of ARARs are categorized as action-specific, chemical-specific, and location-specific. Descriptions of the various ARAR types are provided below: • Chemical-Specific ARARs: Chemical-specific requirements provide health- or risk-based concentration limits or discharge limitations in various environmental media for specific hazardous substances, pollutants, or contaminants. Chemical-specific ARARs are listed in Table C-1 for the LHAAP sites undergoing a Five-Year Review. • Location-Specific ARARs; Location-specific ARARs are restrictions on remedial activities solely based on the location of the remedial activity, such as certain environmentally sensitive areas. Table C-2 lists the location-specific ARARs. • Action-Specific ARARs: Action-specific ARARs are usually technology- or activity-based requirements or limitations or actions taken with respect to hazardous waste sites. Action-specific ARARs are listed in Table C-3. Review of ARARSs for sites covered in this Five-Year Review did not identify any new requirements. Chemical-specific ARARs that may impact cleanup levels are discussed under "Changes in Toxicity and Other Contaminant Characteristics," below in this table.
Changes in Exposure Pathways and Land Use	LHAAP is an inactive, government-owned, formerly contractor-operated and -maintained Department of Defense facility located in central east Texas. The capped LHAAP-12 Landfill was used from 1963 to 1994 for the disposal of industrial solid wastes, possibly containing small quantities of hazardous constituents generated at LHAAP. The site is an open area of grass bounded by heavy timber. According to the ROD (USACE 2006), the land on which this site is located is intended for transfer to the USFWS for incorporation into the Caddo Lake National Wildlife Refuge. Future anticipated use is consistent with an industrial/recreational level of exposure. No change in land use has occurred at LHAAP-12 since the ROD was prepared (USACE 2006). No significant change in exposure pathways has occurred at the site. Both human and ecological receptor populations are also the same. The final selected remedy for LHAAP-12 to protect public health or welfare or the environment includes LUCs and MNA. The site was not released for unrestricted use, but is suitable for nonresidential use. Therefore, the selected remedy is protective of human health and requires no additional evaluation.

Element	Assessment
Changes in Toxicity and Other Contaminant Characteristics	From 1998 to 2004, a BHHRA, a SLERA, and a residential risk screening were conducted (Jacobs 2002a; Shaw 2004 and 2005b). In addition, a plant-wide perchlorate investigation was completed in 2002 (STEP 2005). Media evaluated included soil, groundwater, surface water, and sediment. Receptors evaluated included a current non-source area trespasser, hypothetical future on-site maintenance worker under the industrial scenario, and hypothetical future resident. The BHHRA found that for the current trespasser, none of the exposure pathways contributed to carcinogenic risk and non-carcinogenic hazard. The BHHRA also concluded that the carcinogenic risk and non-carcinogenic hazard for exposure to soil under the industrial and residential scenarios was within the acceptable range. However, the carcinogenic risk and non-carcinogenic hazard from exposure to groundwater were unacceptable; therefore, the RA focused on the groundwater. Table 3-8 compares the groundwater cleanup levels for the COCs established in the ROD (Shaw 2006) with current USEPA maximum contaminant levels (MCLs) and TCEQ medium specific concentrations (MSCs). Multiple ecological evaluations have been performed at LHAAP-12 (Jacobs 2002a; Shaw 2004). Because no chemicals were considered chemicals of ecological concern, no additional characterization of the risk to ecological receptors was necessary for LHAAP-12. Chemicals detected in soil at LHAAP-12 were considered to represent a low threat to the environment (USACE 2006). Therefore, no action was needed at LHAAP-12 for the protection of ecological receptors.
Changes in Risk Assessment Methodologies	Changes in risk assessment methodologies since the ROD was prepared include changes in the estimation of risk from exposure to chemicals via inhalation, and the consideration of the mutagenic mode of action with regard to child receptors. However, these changes would not impact risk assessment conclusions and do not call into question the protectiveness of the remedy for LHAAP-12. Human health risk at these sites has been addressed by the various risk assessments and ROD documentation that led to the final remedy that has been implemented at LHAAP-12.
Toxic Remedy Byproducts	No remedy byproducts have been identified to consider in this assessment.
New Contaminants and Contaminant Sources	No new contaminant sources have been identified.
Expected Progress Toward Meeting RAOs	No changes in the physical condition of LHAAP-12, Landfill 12, have occurred that would affect the protectiveness of the remedy. Exposure assumptions, toxicity data, cleanup levels, and RAOs remain valid for the selected remedies.

Table 3-8: Groundwater Cleanup Levels Comparison for LHAAP-12, Landfill 12

Chemical of Concern	Maximum Concentration	Groundwater Screening Levels (µg/L)			
		ROD Screening Level	Basis	Current MCL	Current MSC[b]
TCE[a]	495	5	MCL	5	5
cis-1,2-DCE	110	70	MCL	70	70
VC	2.1	2	MCL	2	2

Sources: ROD Cleanup Levels: (USACE 2006); current MCLs: (USEPA 2012); current MSCs: (TCEQ 2006).
Notes:

µg/L	micrograms per liter
DCE	dichloroethene
MCL	maximum contaminant level
MSC	medium specific concentration (GW-Ind) for groundwater established by TCEQ
RBSV	risk-based screening values
ROD	Record of Decision
TCE	trichloroethene
TCEQ	Texas Commission on Environmental Quality
USACE	United States Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VC	vinyl chloride

[a] TCE is the primary COC identified in the ROD. Both cancer and non-cancer risks are predominantly associated with exposure to TCE.
[b] Cleanup standards and screening values for the Risk Reduction Rule were last updated in March 2006. According to the TCEQ website (accessed December 12, 2012), these RBSV and MSC tables will not be updated. If a toxicity factor for any COPC has changed, the new toxicity factors are to be used to calculate the new cleanup standard. The 2006 MSCs are still valid for these groundwater COPCs because none of these chemicals had changes in toxicity values since 2006.

3.10.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Answer: None identified.

3.11 Issues

3.11.1 Issues Identified during the Technical Assessment and Other Five-Year Review Activities

Issues identified during the Five-Year Reviews are listed below:

First Five-Year Review	• Groundwater monitoring not conducted regularly • Need O&M Plan • Non-source soils not protected by cap
Second Five-Year Review	• Some minor erosion and unwanted vegetation on landfill cap
Current Technical Assessment (Third Five-Year Review)	• Water level measurements from current network of five wells might not adequately depict groundwater gradient and flow direction • MNA evaluation is limited to one well within the plume; this well was found dry during the December 2012 sampling event • Possible seasonal effects on VOC concentrations in groundwater and groundwater elevation drop in the VOC plume area.

3.11.2 Determination of Whether Issues Affect Current or Future Protectiveness

The issues identified during the previous Five-Year Reviews have been addressed per recommended follow-up actions. One issue identified during this Five-Year Review affects future protectiveness and optimization of the MNA network is recommended to address it. The remaining issues identified do not affect current or future protectiveness because:

- VOCs remain non-detected in compliance wells 12WW22 and 12WW23 as demonstrated by sampling events in July 2010, July 2011, and December 2012. This ensures that TCE from groundwater is not migrating to surface water at Central Creek.
- Exposure of contaminated groundwater to onsite receptors is eliminated through LUCs (prohibiting groundwater use and restriction on the installation of water production wells).

3.11.3 Unresolved Issues

None

3.12 Recommendations and Follow-up Actions

Based on this Five-Year Review, the issues, recommendations, and follow-up actions are presented in Table 3-9.

3.13 Protectiveness Summary

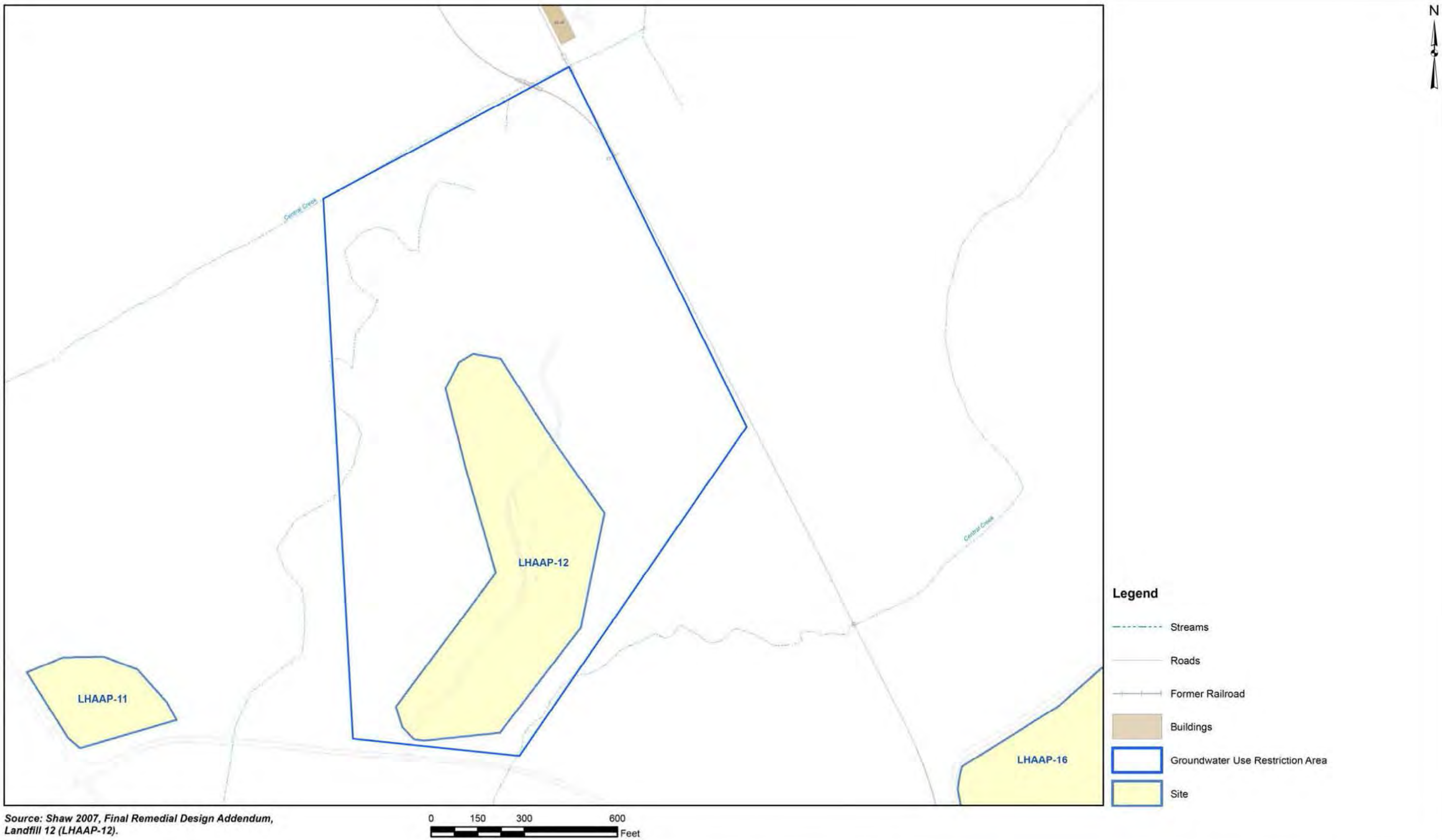
The Final RA (cap, LUCs and MNA) at LHAAP-12 currently protects human health and the environment by reducing the leaching and migration of hazardous substances, preventing contaminated groundwater from migrating to surface water, and preventing human exposure to contaminated groundwater. Replacement of 12WW24 and an evaluation of whether expansion of the current monitoring well network and re-evaluation of possible seasonal effect on VOC concentrations and groundwater flow will enhance long-term protectiveness.

3.14 Next Review

LHAAP is required to perform Five-Year Reviews. The next review will be conducted within five years of the completion of this Five-Year Review report. According to EPA guidance (2001) section 1.3.3, completion or the trigger for subsequent reviews corresponds to EPA's concurrence signature date.

Table 3-9: Recommendations/Follow-up Actions for LHAAP-12

Issue	Recommendation/Follow-up Action	Party Responsible	Oversight Agency	Milestone Date	Affects Current Protectiveness?	Affects Future Protectiveness?
Minor erosion of the landfill cap	Repaired erosion in June 2013	USACE	State/ USEPA	July 2014	No	Yes
Minor subsidence of the landfill cap	Backfilled and seeded in June 2013	USACE	State/ USEPA	July 2014	No	Yes
Part of fencing not intact	Replace fence, as needed, to securely display warning signage.	USACE	State/ USEPA	July 2014	No	Yes
Water level measurements from current network of five wells might not adequately depict groundwater gradient and flow direction	Add older wells into the water elevation data set for an expanded picture of groundwater gradient and flow direction.	USACE	State/ USEPA	July 2014	No	Yes
Well within the plume found dry during December 2012 sampling event. MNA evaluation is limited to one well within the plume Possible seasonal effects on VOC concentrations in groundwater and groundwater elevation drop in the plume area	Install well adjacent to the dry well Re-evaluate the LHAAP-12 MNA Network Re-evaluate the LHAAP-12 MNA Network	USACE	State/ USEPA	July 2014	No	Yes



Source: Shaw 2007, Final Remedial Design Addendum, Landfill 12 (LHAAP-12).

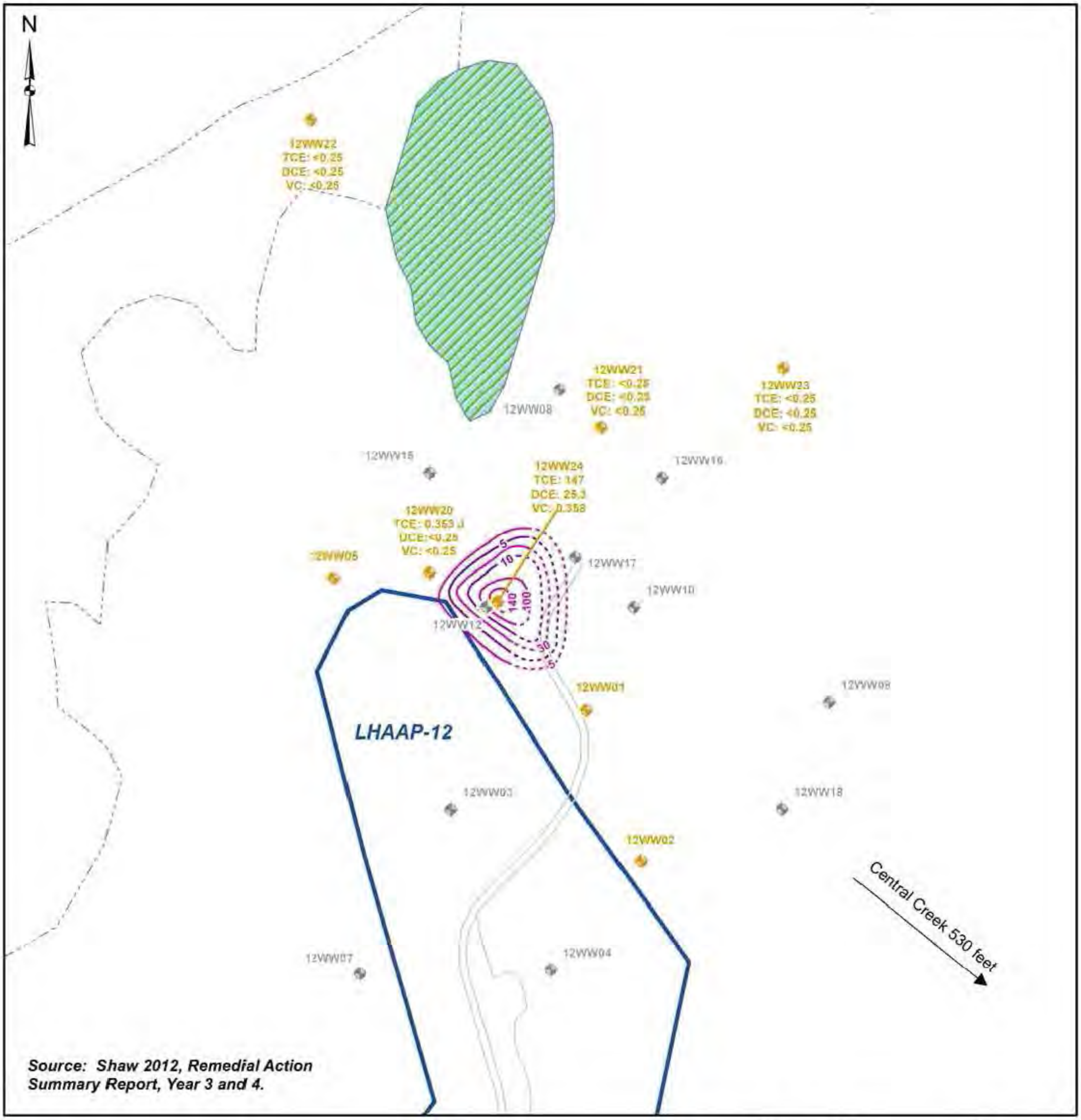
AECOM

Figure 3-1
Groundwater Use Restriction Area
LHAAP-12

Longhorn Army Ammunition Plant
Karnack, Texas

60256135

May 2013



Legend

- Existing Shallow Monitoring Well
- Abandoned Shallow Monitoring Well
- TCE (Trichloroethene) Concentration Isopleth (Dashed Where Inferred)
- cis-1,2-DCE (Dichloroethene) Concentration Isopleth (Dashed Where Inferred)
- Streams
- Roads
- Drainage Feature
- Site (Boundary of Landfill Cap)

0 100 200 400 Feet

Notes:
1. Concentrations reported in µg/L.
2. Concentrations shown ar 12WW20, 12WW21, 12WW22, 12WW23, and 12WW24 are from June 2011 sampling event.
3. MCL (Maximum Contaminant Level) for TCE if 5 µg/L, for DCE is 70 µg/L, and for VC is 2 µg/L.
4. "DCE" Concentrations indicated cis-1,2-DCE.

AECOM

Figure 3-2
2011 Groundwater Contamination Plume Map
LHAAP-12
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

May 2013

4 LHAAP-16

4.1 Site Chronology

Significant events relevant to site LHAAP-16 are presented in Table 4-1. In addition to the events leading up to implementation of the interim remedy, this table provides a chronology of subsequent events up to the present.

Table 4-1: Chronology of Site Events for LHAAP-16[1]

Event	Date
Land Disposal Study No. 38-26-0104, LHAAP. AEHA installed and sampled three monitoring wells at Old Landfill (Site 16)	1980
EPS installed one monitoring well (MW-122) and collected groundwater and soil samples.	1987
RFA reviewed all sites at LHAAP and assigned numbers currently in use to identify them.	April 8,1988
LHAAP placed on NPL	August 29, 1990
LHAAP, Texas Water Commission (later TNRCC and now TCEQ), and USEPA enter into a CERCLA Section 120 Agreement for remedial activities at LHAAP, referred to as the FFA	December 30,1991
RCRA Part B Permit signed.	February, 1992
Phase I Field Investigation by Sverdrup installed eleven monitoring wells, seven soil borings and collected sediment, groundwater, and surface water samples	1993
Phase II Field Investigation by Sverdrup installed seven monitoring wells, drilled ten soil borings, and collected twenty-one Geoprobe samples	1995
USACE begins quarterly sampling of surface water	1995
Final Report-LHAAP Installation Restoration Program, Sites 12 and 16 IRA Focused FS, recommends cap design for Sites 12 and 16	March 1995
Final ROD for Early IRA at Landfill Sites 12 and 16	September 1995
USACE did a post-Phase II investigation, collecting surface water and installing two extraction wells and twelve piezometers	August 1995
Two pilot extraction wells and twelve piezometers installed by Sverdrup as part of Groundwater Treatability Study (TS)	February 1996
Final Project WPs, IRA Landfill 12 and 16	June 10, 1996
IRA Construction start date	October 25, 1996
As part of Phase III investigation, Sverdrup installs eight piezometers and twenty monitoring wells. Six more extraction wells were installed under the Accelerated RI to contain contamination seeping from groundwater into Harrison Bayou. Water to be piped to the GWTP. Groundwater, soil, surface, and sediment samples collected.	June 1997
35,840 cubic yards of treated soil placed in landfill from LHAAP-18/24 and capped	1997
As part of Phase III investigation, Sverdrup collects Geoprobe and groundwater samples	1998
Landfill Cap LTM started	1998
Final Sampling and Data Results Report, Site 16 Phase III RI/FS and Groundwater TS, LHAAP	December 1998
Final Construction Completion Report, IRA, Landfills 12 and 16 Cap Construction, LHAAP	December 1998

Event	Date
IRA Construction completion date	August 31, 1999
Site 16 Draft RI/FS	August 1999
Final Human Health Risk Assessment	June 2001
Draft Final FS for Site 16	December 2001
Final Feasibility for Site 16	March 2002
Second Quarter Data for Perchlorate Investigation	2002
Final Five-Year Review for Sites 18 & 24 (BG3), Site 16 (Old Landfill), and Site 12 (Sanitary Landfill)	August 2002
Three additional monitoring events	2003-2004
Study of enhanced *in-situ* bioremediation of perchlorate at LHAAP-16	2003-2005
Environmental Site Assessment, Phase I and II Report, Final	February 2005
STEP issues Final Plant-Wide Perchlorate Investigation for the LHAAP. For the groundwater at LHAAP-16, the report recommends continuation of monitoring and consideration of remedial measures to reduce the levels of perchlorate.	April 2005
Draft Baseline Ecological Risk Assessment (BERA) was submitted to regulatory agencies for approval	March 2007
Draft Final MNA Plan, LHAAP-16	March 2007
Final Addendum 11 MNA Sampling LHAAP-16, -17, -29, -46, -47, -50, -35A(58), Final Installation-Wide Work Plan	May 2007
Installation and Sampling of Wells near Harrison Bayou	2007
Final BERA approved	November 2007
Sampling and Analysis for Metals, Perchlorate, and VOCs	2009
Final Second Five-Year Review Report for LHAAP-12, LHAAP-16 and LHAAP-18/24	October 2008
Final Addendum to Final FS	March 2010
Draft ROD, LHAAP-16 Submittal	June 2011
Draft Final ROD, LHAAP-16 Landfill 16	September 2011

[1]Sources: Shaw 2008, Shaw 2011

4.2 History of Contamination

The location of LHAAP-16, the Old Landfill, is shown on Figure 2-1 and site features are shown on Figure 4-1. This site was originally used from 1942 to 1944 for the disposal of TNT red water ash. The central section of the site was reportedly used as an all-purpose junkyard for disposal of such materials as substandard TNT, barrels of chemicals, oil, paint, scrap iron, and wood. In the mid to late 1950s, rocket motor casings were reportedly burned and possibly buried at the site. Burn pits, waste storage, and landfill operations continued as waste disposal and treatment activities until sometime in the 1980s. As early as 1980, an AEHA land disposal study recommended changes in disposal practices due to leachate escaping from the landfill. Leachate from the landfill is considered the source of groundwater contamination by VOCs and perchlorate at LHAAP-16 (Shaw 2008).

4.3 Initial Response

In 1976, the AEHA identified a suspected release of contaminants from the site. As a result of the AEHA Air and Water Pollution Survey, monitoring wells were first installed at the site in 1980. Landfill 16 ceased to be utilized for waste disposal in the 1980s (U.S. Army 1995).

In 1990, LHAAP was placed on the NPL, and in 1991, the U.S. Army, USEPA, and TWC entered into an FFA designating LHAAP as a "fence to fence" site. LHAAP-16 was included in the FFA as a solid waste management unit (U.S. Army 1991).

An IRA ROD (USACE 1995) was finalized in September 1995, directing the capping of the landfill. Construction to place a cap on the landfill began in 1996. Approximately 35,840 cubic yards of treated soil from LHAAP-18/24 Thermal Desorbers was placed in LHAAP-16 as a grading layer of the cap (Shaw 2008). The cap was completed in 1999, the site was fenced with barbed wire, and warning signs were placed around the landfill. In addition, a groundwater extraction system was voluntarily installed by the U.S. Army in 1996 and 1997 as a TS to prevent the groundwater plume from migrating to Harrison Bayou (Shaw 2010a). Groundwater is extracted from LHAAP-16 and pumped to an existing GWTP at LHAAP-18/24. Although the intended duration of operation of the extraction system at LHAAP-16 was 24 months, the system has been operating for over 10 years and has contributed to the mitigation of contaminant migration.

The FS, presenting an interim analysis of remedial alternatives for LHAAP-16, was issued in March 2002 (Jacobs 2002b). This FS did not address ecological risk or final groundwater remediation. Subsequent to the FS, a number of investigations were performed that provided further information regarding LHAAP-16. Those investigations were as follows:

- A plant-wide perchlorate investigation in 2002 (STEP 2005)
- Three additional monitoring events in 2003 and 2004 (USACE and ALL Consulting 2006)
- Sampling and analysis of MNA parameters in 2007 (Shaw 2010a)
- Installation and sampling of wells near Harrison Bayou in 2007 (Shaw 2011)
- Installation and sampling of wells to address data gaps in 2008 (Shaw 2010a)
- Sampling and analysis for metals, perchlorate, and VOCs in 2009 (Shaw 2010a)

A FS Addendum (Shaw 2010a) presenting the final remedy was issued in March 2010. The Draft Final ROD documenting the proposed final remedy was issued in September 2011. The ROD was disputed by USEPA and is in dispute resolution.

4.4 Basis for Taking Action

As stated in the ROD for IRA at the LHAAP-16 Landfill, the action was "necessary to mitigate potential risks posed by buried source material." While a formal risk assessment had not been completed for the site at the time of the interim ROD, environmental investigations had revealed low to moderate levels of contaminants in the soil and groundwater at the landfill Contaminants at LHAAP-16 included TCE, cis-1,2-DCE, and methylene chloride (MC) in soil, and TCE and MC in groundwater. The close proximity of Harrison Bayou to LHAAP-16 increased concerns about migration of contaminants from groundwater to surface water. The stated remedial objectives for the IRA were to minimize long-term vertical infiltration of water through the landfill; and minimize contaminant transport (U.S. Army 1995).

The presumptive remedy IRA was implemented in 1996 through 1998 by placement of a multilayer cap at LHAAP-16, mitigating potential risks posed by buried landfill waste (OHM 1998). The cap prevents rainfall from vertically infiltrating the landfill and mitigates contaminant transport.

4.5 Remedial Actions

4.5.1 Regulatory Basis for Action

The IRA ROD for LHAAP-16 established an IRA to mitigate potential risks posed by buried source material at the site. The U.S. Army issued the IRA ROD on September 27, 1995 (USACE 1995).

The Draft Final ROD (Shaw September, 2011) was disputed by USEPA and remains in dispute resolution. The USEPA (Region 6) and TCEQ are the regulatory agencies providing technical support, project review and comment, and oversight of the LHAAP cleanup program.

4.5.2 Remedial Action Objectives

The RAOs for the interim remedy for LHAAP-16 which address the landfill source material and the contamination associated with it are:

- Minimize long-term vertical infiltration of water through the landfill; and,
- Minimize contaminant transport.

The IRA RAOs were achieved with the construction of the landfill cap, a presumptive remedy, and institution of LUCs for the protection of the cap. A groundwater monitoring program was also implemented to assure prevention of exposure.

4.5.3 Remedy Description

A landfill cap was installed in 1998 as part of the early IRA to mitigate potential risks posed by buried source material at the site. The cap includes the following components:

- Foundation soil layer
- Low permeability sodium bentonite geocomposite
- Geosynthetic membrane liner
- Final soil cover with adequate slopes and vegetation
- Perimeter berms and drainage swales to control surface water runoff.

The IRA ROD included LUCs such as warning signage, use restrictions, regular inspections, maintenance, and repair of the cap.

The anticipated components of the final remedy are listed below. The final remedy is in the decision phase.

- Maintenance and repair of the existing landfill cap. Groundwater monitoring activities at select wells also will be conducted to evaluate the effectiveness of the existing landfill cap. The need to continue groundwater monitoring for this purpose will be evaluated at Five-Year Reviews.
- Treatment of groundwater by *in-situ* enhanced bioremediation in the more contaminated areas and installation of biobarriers to reduce contaminant mass and control contaminated groundwater from migrating into Harrison Bayou. This will be supplemented by MNA. Bioremediation will be implemented in conjunction with a phased shut-down of the existing groundwater extraction system.
- MNA to be implemented for areas outside the influence of the active remedies to assure protection of human health and the environment by documenting that further reductive dechlorination is occurring within the plume and that contaminant concentrations are being reduced to cleanup levels. If MNA is not successful, a contingency remedy will be implemented. That contingency remedy will comprise injection of bioremediation amendments in locations that are selected based on evaluation of site data available at that time.
- Groundwater monitoring to be conducted to evaluate inorganic COCs. The need to continue groundwater monitoring for this purpose will be evaluated at five year reviews.
- Surface water monitoring to be conducted to confirm that surface water standards for the contaminants and by-product contaminants are not exceeded in Harrison Bayou, which flows into Caddo Lake.
- LUCs to prevent human exposure to the landfill waste. The LUCs will remain in place as long as the landfill waste materials remain at the site. In addition, LUCs restricting the potable use of groundwater above the cleanup levels and restricting land use to nonresidential until the levels of COCs in soil and groundwater allow for unlimited use and unrestricted exposure.
- CERCLA Five-Year Reviews including inspections.

4.5.4 Remedy Implementation

Maintenance/repair of the existing cap and LUCs instituted during the IRA have been implemented. The IRA included the construction of a landfill cap, now considered a component of the anticipated final remedy at LHAAP-16. Construction of the 13-acre multilayer cap was completed in 1999. Since June 2000, the cap has been monitored, maintained, and repaired, as necessary, to ensure its long-term effectiveness (Shaw 2008). In accordance with the IRA ROD, LUCs such as warning signage and maintenance and repair of the cap are currently in place. Routine maintenance (e.g., mowing, aerating, seeding, settlement, etc) and erosion repair, are also being performed to ensure that the integrity of the soil cover is maintained. A groundwater monitoring program is in place to assure prevention of exposure.

A groundwater extraction system with eight wells has been in operation since 1996. The extraction system is currently operating as a Treatability Study (TS) to prevent the COCs from migrating to Harrison Bayou. The locations of the extraction wells are shown in Figure 4-1. The extraction wells were installed as four pairs ("nests"), each consisting of a shallow well (wells

16EW01-16EW04) installed to a depth of approximately 35 feet and screened in the shallow saturated zone, and an intermediate well (wells 16EW05-16EW08) installed to a depth of approximately 55 feet and screened in the intermediate saturated zone. These extraction wells are located in the most contaminated portion of the shallow and intermediate groundwater zones. Although the extraction wells were designed for an optimum combined flow rate of 8 gpm, historically they have produced an average of about 2 gpm (Jacobs 2002b). The extracted groundwater is pumped to an existing GWTP at LHAAP-18/24. The extraction system produced 2,194 gallons of water in the 2nd quarter of 2012 (Shaw 2012c) and 253,259 gallons (AECOM 2013c) in the first quarter of 2013 from LHAAP-16 following equipment repairs and replacement. This increase in extraction volume in 2013 is a result of an improved maintenance program that resulted in repair or replacement of the pumps, motors, and switch levels. The extraction system was temporarily shut down periodically for the above repairs and continues to be in operation to date. As part of the final remedy, it is anticipated that bioremediation will be implemented in this portion of the plume, in conjunction with phased shut-down of the existing groundwater extraction system.

4.6 Compliance Monitoring

Compliance monitoring at LHAAP-16 consists of daily monitoring of flow rates from extraction wells to proactively identify issues or needed repairs, annual SIs, a regular groundwater monitoring program including collection of monthly water levels, analytical sampling of the extraction system wells, occasional analytical sampling of select monitoring wells, surface water sampling, and Five-Year Reviews. With the exception of the surface water sampling, the data associated with these efforts is compiled in quarterly reports associated with LHAAP-18/24 and the GWTP. Surface water monitoring results are reported through hand-outs at Restoration Advisory Board meetings and are periodically added to the Administrative Record.

The U.S. Army inspects all land use restrictions and controls for LHAAP-16 on an annual basis to determine the effectiveness and compliance with these restrictions and controls. The inspections include determining any violations of the LUCs, as well as indicators of cap degradation, maintenance issues, trespass, and incompatible use.

Groundwater monitoring is conducted in accordance with the *Sampling and Analysis Plan* [SAP] *Groundwater Treatment Plant and Well Fields* (Shaw 2007e), which is periodically updated and revised along with the installation or abandonment of wells. Groundwater monitoring consists of collection of samples from the eight extraction wells (16EW01-16EW-08) on an annual basis. Samples are analyzed for VOCs, perchlorate, and chloride. In addition, groundwater elevations are measured from twenty piezometers. The results are presented in the quarterly GWTP evaluation reports (most recently, AECOM 2013).

Because contaminants remain at LHAAP-16 above levels that allow for unlimited use and unrestricted exposure and a final remedy is not yet in place, a Five-Year Review is conducted every five years to ensure protection of human health and the environment under CERCLA §121(c), U.S. Code (U.S.C.) Title 42 §9621(c).

4.7 Systems Operations and Maintenance

In addition to O&M activities associated with the extraction system, LUC inspection, cap maintenance, and groundwater water and piezometer monitoring are routinely performed at

LHAAP-16 in conjunction with the O&M activities at LHAAP-18/24.This information is reported in monthly and quarterly GWTP reports which were completed throughout the review period. The extraction system is not part of the IRA but acts to enhance the effectiveness of the cap in controlling migration of contaminated groundwater.

As part of the landfill inspections, wells are visually inspected during sampling activities and mowing, weeding, and brush clearing activities are completed. Daily checks of system components are completed in the field. Damage or irregularities to the wellheads, communication lines, tanks or other components are reported at the time they are identified and recorded in field notes or on sampling forms, and were repaired when needed. Monitoring data are uploaded in the project database, as available.

4.7.1 Treatment or Other System Processes

Although there is no treatment associated with the IRA, the groundwater extraction system that operates as a result of a TS and enhances the protectiveness of the cap consists of eight extraction wells (four in the shallow zone and four in the intermediate zone), a 60,000 gallon storage tank, and a double-containment pipeline from the tank to the GWTP. Additionally, the system communicates with the GWTP via the programmable logic controller allowing remote monitoring of system conditions and flow. Data and information developed for this system is reported in monthly and quarterly reports associated with the GWTP.

Since the installation of the groundwater extraction system in 1997, the on-site contractor for the GWTP has been responsible for operating and maintaining the extraction system. The well pumps are removed for maintenance regularly. Other maintenance activities include cleaning check valves, changing the oil in the compressor, and sampling at the extraction wells. The extraction system maintenance is currently performed by AECOM under contract with USACE.

The O&M activities associated with the cap have been provided by different contractors since 1998. USACE currently contracts with AECOM to provide O&M activities for LHAAP-16. From June 2000 to December 2005, CES performed O&M. Prior to June 2000, Radian performed the O&M activities. The primary O&M activities for the landfill cap are as follows:

- Maintain the signs and mow the associated areas at LHAAP-16
- Inspect the cap and perform repairs as required
- Maintain LUCs at LHAAP-16

As part of routine maintenance, physical inspection of cap was performed daily (work days only) with minor repairs scheduled, planned and implemented as they were identified. Other than the presence of a few tree seedlings observed during June 2011 inspection, all findings were noted as satisfactory. Apart from some minor erosion/subsidence identified and repaired with the addition of soil and vegetation in 2012, there were no signs of erosion or desiccation cracks, dead vegetation, burrowing animals or subsidence at or around the landfill cap. The tree seedlings were removed in July 2011.

Although maintenance occurred throughout the review period, the groundwater extraction system was fully overhauled (all pumps either repaired or replaced, PLC cables repaired, well field maintenance completed) in 2012 and 2013 and continues to be in operation to date.

4.7.2 Operations and Maintenance Costs

The approximate costs for O&M and LTM activities at LHAAP-12, LHAAP-16, and LHAAP-18/24 are not subdivided into individual site estimates, thus assessment of individual site cost performance is not possible. The original O&M total cost estimate for LHAAP-12 and LHAAP-16, and cost estimate for LHAAP-12 RAO LTM, was $75,000/year (USACE 1995a). The original O&M total cost estimate for LHAAP-18/24 was $400,000/year (USACE 1995b). The combined approximate actual O&M and LTM cost estimates for sites LHAAP-12, LHAAP-16 and LHAAP-18/24 are presented in Table 4-2.

Table 4-2: O&M and LTM Costs for LHAAP-12, LHAAP-16 and LHAAP-18/24

Calendar Year	O&M Approximate Actual Costs	LTM Approximate Actual Costs
2008	$416,328	$247,127
2009	$354,210	$112,240
2010	$354,205	$102,188
2011	$354,205	$38,628
2012	$1,118,889	$108,666

From 2007 through 2011 the annual estimates are stable or decreasing. The increased costs for 2012 are due to recapitalization to complete deferred maintenance and essential upgrades to equipment and are not indicative of any effects on protectiveness with repairs and upgrades enhancing effectiveness.

4.8 Progress Since the Last Five-Year Review

This section provides a record of progress at LHAAP-16 since the completion of the second Five-Year Review in 2008. The most significant progress made has been the issuance of the Draft Final ROD (Shaw 2011), which is in dispute resolution.

4.8.1 Previous Protectiveness Statements and Recommended Actions

The protectiveness statements from the previous Five-Year Reviews (CES 2002; Shaw 2008) are presented in Table 4-3. The recommended actions from the previous reviews are listed in Table 4-4.

Table 4-3: Protectiveness Statements from Previous Reviews

First Five Year Review (CES 2002)

The RA at LHAAP-16 is expected to be protective of human health and the environment by serving its intended purpose to reduce the potential for vertical infiltration of water through the landfill. With the addition of eight extraction wells as part of the accelerated RI/FS, the RA meets the objective to minimize contaminant transport. The removal action and operation of the eight extraction wells assist in protection of the environment and human health by greatly reducing the chance of contaminants leaving the site. For the RA to be effective, the extraction wells will remain in operation. As an Early RA this was not intended to be final solution. A FS is still in progress.

Future remedies at LHAAP-16 need to evaluate the following:

- The effectiveness of the cap needs to be evaluated through regular groundwater monitoring.
- Determine if additional monitoring wells and piezometers need to be installed between the landfill and Harrison Bayou.
- The Baseline Risk Assessment for Human Health states, "Based on the results of the Site 16 baseline risk assessment, it appears that groundwater is the primary medium of concern at the site. The hypothetical future use of groundwater should be evaluated by 1) identifying the effect of the current groundwater extraction system on groundwater concentrations relative to potential future site uses, and 2) identifying the potential for contaminants identified in onsite groundwater to migrate off-site.
- LHAAP-16 needs additional ecological risk assessment work before a final decision can be made concerning the final remedy.

Second Five Year Review (Shaw 2008)

The IRA at LHAAP-16 currently protects human health and the environment because the cap minimizes the infiltration of water into the landfill, thus reducing the possibility of contaminant transport. The extraction wells associated with the 1997 TS provide increased protectiveness by establishing hydraulic control in an area between the landfill and the bayou. This Five-Year Review found that the remedy was constructed in accordance with the requirements of the IRA ROD for LHAAP-16, and that the cap was being maintained sufficiently to satisfy the objectives of the IRA. LUCs (e.g., signs) are in place to protect the cap. Comparison of contaminant data before and after implementation of the interim remedy indicates that the TCE concentrations are generally decreasing in the wells downgradient of the extraction wells, which demonstrates the effectiveness of the cap and the extraction system in controlling the migration of landfill contaminants toward the surface water.

While the cap was installed as part of an early interim remedy, capping is a presumptive remedy for military landfills and was intended to be consistent with the final remedy at LHAAP-16. In accordance with the RI/FS process, a risk assessment for human health was prepared in 2001, and a BERA was prepared in 2007. The FS addendum will be finalized to evaluate alternatives for a final remedy at the site. Within the FS, the existing cap and extraction wells will be evaluated, along with other technologies, as components of the final remedy.

Table 4-4: Recommendations for LHAAP-16 from Previous Reviews

Issue	Recommendation/Follow-up Action	Party Responsible	Oversight Agency	Milestone Date	Affects Current Protectiveness?	Affects Future Protectiveness?	Action Taken	Date of Action
Status of Recommended Actions from First Five-Year Review (CES 2002)								
Groundwater monitoring not conducted regularly	Monitoring wells on a regular basis	USACE	State/USEPA	5/30/02	No	Yes	USACE performed limited sampling Regular sampling of the most contaminated portion of the groundwater initiated with the installation of groundwater extraction system	2003/2004 2006
Need O&M Plan	Write and implement an O & M Plan	USACE	State/USEPA	5/30/2002	No	Yes	Open Item	See Section 4.13
Ecological Risk Assessment not Complete	Proceed to Step 3 of the Superfund Ecological	USACE	State/USEPA	5/30/2002	Yes	Yes	BERA was issued and approved	November 2007
Evaluate the hydrogeologic effectiveness of groundwater extraction system	Perform study to determine impact of other contaminants on environment	USACE	State/USEPA	3/30/2002	Yes	Yes	Shaw has examined this during RI/FS work. The system is marginally effective, but may not be needed as a long-term remedy	2007
Groundwater model in RI/FS should provide modeling of perchlorate and possibly other contaminants	Perform study to determine impact of other contaminants on environment	USACE	State/USEPA	3/30/2002	Yes	Yes	Modeling was performed and submitted to regulatory agencies as part of the natural attenuation evaluation	2007
Steel covers off housing at extraction wells	Place covers on housing or replace with lighter covers more easily moved	CES/USACE	State/USEPA	3/30/2002	No	No	Aluminum covers were installed	2002
Status of Recommended Actions from Second Five-Year Review (Shaw 2008)								
Need O&M plan	Prepare O&M Plan for the landfill	U.S. Army	State/USEPA	12/31/08	No	Yes	Required O&M activities for the LHAAP-16 Landfill were identified in Part VI of the Early IRA Design. The U.S. Army has expanded on that general guidance by preparing a checklist for landfill inspection. The March 2009 inspection of the LHAAP-16 Landfill was based on the Early IRA Design requirement for semi-annual inspections.	December 2008 (located IRA Design) March 2009 (conducted inspection)
Groundwater monitoring (chemical sampling and water levels)	Implement regular groundwater monitoring program	U.S. Army	State/USEPA	12/31/08	No	Yes	Selected monitoring wells in the shallow, intermediate, and upper deep zones at LHAAP-16 will now be sampled on the same semi-annual schedule as the groundwater sampling that is performed at LHAAP-18/24. The revised monitoring wells were included in the March 2009 sampling event. A baseline sampling event to establish current conditions for all wells was completed in April 2013	December 2008 (added wells to semi-annual sampling program) March 2009 (sampling event)
Some minor erosion and unwanted vegetation on landfill cap	Repair erosion and remove small pine trees	U.S Army	State/USEPA	12/31/08	No	Yes	The pine trees were sprayed with herbicide in December 2008. The caps were inspected in March 2009, and the decision was made to spray again. That spraying occurred in June and July 2009. Erosion locations are being observed during each inspection. Areas that erode further will be repaired with clean fill and seeded.	July 2009. Erosion and cap vegetation will continue to be evaluated in semi-annual inspections.

Issue	Recommendation/Follow-up Action	Party Responsible	Oversight Agency	Milestone Date	Affects Current Protectiveness?	Affects Future Protectiveness?	Action Taken	Date of Action
Age and condition of piezometers	Inspect condition of piezometers during monitoring activities and, when applicable, identify for repair, replacement, or abandonment	U.S Army	State/USEPA	12/31/08	No	Yes	Due to lack of information about their construction, the degree of silting at the piezometers cannot be determined. Given the concerns about their condition, Shaw has stopped using the piezometers for potentiometric surface maps. Water levels were measured monthly through April 2009, but Shaw no longer measures water depths at the piezometers. The piezometers will be abandoned when the final remedies are implemented at LHAAP-16 and -18/24. Plan also to assess the need for the piezometers based on current groundwater data during RD, and abandon the ones determined to be no longer suitable	Deferred to final remedies.

4.8.2 Status of Ongoing Activities

The interim remedy of capping at LHAAP-16 was completed in 1999 in accordance with the IRA ROD (USACE 1995). A groundwater extraction system was voluntarily installed by the U.S. Army in 1996 and 1997 as a TS to prevent the groundwater plume from migrating to Harrison Bayou (Shaw 2010a). This system continues to operate as of the date of this Five-Year Review and recent updates to the LHAAP-18/24 GWTP have increased the system efficiency.

Since the completion of the landfill cap, several investigations were conducted to further evaluate the nature and extent of contamination in the soil, groundwater, surface water, and sediments at LHAAP-16. The results of the multi-phase investigations for the various media at LHAAP-16 between 1993 and 1999 are documented in the RI Report (Jacobs 2000). Using data from the investigations conducted through 1999, a BHHRA (Jacobs 2001a) and an addendum to the BHHRA (Jacob 2001b) were completed to support the FS. The BHHRA addressed the non-source area (soil outside the landfill) that could have become contaminated from spill and leaks. The Final FS Report (Jacobs 2002b) presented an interim analysis of remedial alternatives, since the final ecological risks and extent of groundwater remediation were not addressed in that document.

Subsequent to completion of the final FS in March 2002, a number of investigations were performed that provide additional information regarding LHAAP (Shaw 2010a). Remediation alternatives considered in this FS were interim alternatives pending anticipated site-wide ecological risk assessment and determination on the extent of groundwater restoration required at Site 16 along with other sites in the area. The investigations are summarized below.

- Perchlorate sampling was conducted at LHAAP-16 in March and September 2002 (STEP 2005). Perchlorate was detected in several shallow- and intermediate-zone monitoring wells with a maximum concentration of 2,430 µg/L in the shallow zone and 1,950 µg/L in the intermediate zone (Shaw 2010a).
- Since 1999 to present, surface water monitoring has been conducted on a quarterly basis at LHAAP-16. Surface water samples are collected from three locations in Harrison Bayou: upgradient, downgradient, and immediately adjacent to LHAAP-16. Surface water analytical results indicated that in the past there has been some discharge by seepage into Harrison Bayou (Shaw 2011).
- Groundwater monitoring was completed for spring 2003, spring 2004, and winter 2004 sampling events at LHAAP-16 (USACE 2007). Groundwater samples collected from twenty-nine monitoring wells were analyzed for anions including perchlorate, and explosives, VOCs, and metals. The primary contaminant detected during the three rounds of monitoring at LHAAP-16 was TCE (Shaw 2010a).
- Additional groundwater sampling, including installation of new wells, was conducted between June 2007 and 2008. The 2007 data, together with historical results from the site, were used to prepare an initial MNA evaluation for the site. In March 2009, additional groundwater sampling was performed for 21 monitoring wells and eight extraction wells at LHAAP-16. The groundwater sampling results are presented in the Addendum to Final FS Report, issued in March 2010 (Shaw 2010a).

4.9 Five-Year Review Component

4.9.1 Administrative Review

The LHAAP Five-Year Review team was led by Dave Wacker (AECOM), who serves as AECOM Project Manager for LHAAP. The overall team was composed of the members listed in Table 4-5.

Table 4-5: Five-Year Review Team

AECOM	Project Manager: Dave Wacker Senior Engineer: Naseem Hasan, P.E. Chemist: Celia Flores Senior Review: Anne Lewis-Russ, Ph.D. Senior Risk Assessor: Rotha Randall Senior ARAR Assessor: Ruth Hammervold
LHAAP	Site Manager: Rose Zeiler
USACE	Project Engineer: Aaron Williams, P.E.
TCEQ	Remedial Project Manager: April Palmie
USEPA	Remedial Project Manager, Rich Mayer, P.G.
USFWS	Paul Bruckwicki
RAB	RAB Co-Chair: Paul Fortune
RAB	RAB Co Chair: Judith Johnson RAB Member: Richard LeTourneau

The review included the following activities:

- Review of relevant documents
- Data review
- SIs
- Local interviews
- Community involvement.

The Five-Year Review was conducted in accordance with the USEPA Comprehensive Five-Year Review Guidance (USEPA 2001). The purpose of the Five-Year Review is to determine whether the remedies selected and implemented are protective of human health and the environment. This Five-Year Review report documents any deficiencies identified during the review and recommends specific actions to ensure that a remedy is protective.

4.9.2 Community Involvement

Community notification was accomplished via interviews and publishing a notice in the local paper. The public notice was published in the Marshall News Messenger on December 14, 2012. When the Five-Year Review report is finalized, another notice will be published to indicate that the report will be available to the public at the Marshall Public Library (300 South Alamo Boulevard in Marshall, Texas 75670). The public notice is presented in Appendix B.

4.9.3 Document Review

This Five-Year Review consists of a review of relevant documents including RODs, RIs, FSs, risk assessments, completion reports, LTM data (project database), LUC inspection reports, and various compliance reports. Applicable groundwater and other cleanup standards, as listed in the RODs for LHAAP-16, were reviewed; details regarding the review are provided in Appendix C. The list of documents reviewed is provided in Appendix E1.

4.9.4 Data Review

As indicated in the approval letter from the USEPA to U.S. Army on August 31, 1999, the OHM Remediation Services December 1998 document entitled "*Final Construction Completion Report, IRA, Landfills 12 and 16 Cap Construction*" provides a record of the capping of the landfill at LHAAP-16. The data review portion of this Five-Year Review focuses on monitoring and extraction well data and SI results.

4.9.4.1 Potentiometric Surface

Groundwater elevations were measured by Shaw in June 2007 (Shaw 2011). The shallow zone groundwater elevation contours based on these data are shown on Figure E2-1(presented in Appendix E2). Depth to groundwater in the shallow zone is approximately 4-25 feet bgs. The shallow groundwater zone varies in thickness from 9-18 feet and extends 33 feet bgs. An intermediate groundwater zone containing fewer fines than the shallow zone extends from 35-62 feet bgs (Figure E2-2 presented in Appendix E2). The upper deep groundwater zone extends from approximately 80-151 feet bgs. The deep groundwater zone extends below 220 feet bgs.

While flow is primarily horizontal in these zones, vertical interaction between the shallow and intermediate zones is evidenced by pumping test results as well as the presence of contamination in both zones. The groundwater flow direction is generally to the east toward Harrison Bayou in the shallow zone (Figure E2-1) and the intermediate zone (Figure E2-2). Groundwater flow between the landfill and Harrison Bayou is also influenced by the presence of the extraction system.

4.9.4.2 Contaminants

The groundwater COCs identified in the Draft Final ROD (Shaw 2011) are TCE, cis-1,2-DCE, VC, perchlorate, and five metals (arsenic, chromium, manganese, nickel, and thallium). Groundwater monitoring at LHAAP-16 has been conducted under several programs as described in section 4.8.2. Monitoring wells within and in the vicinity of the TCE and perchlorate plumes have been monitored since 1995. Samples have been collected from shallow and intermediate zones.

TCE and perchlorate data for samples collected from the extraction and monitoring wells were assessed to determine if the current remedy-in-place is effectively controlling migration of contaminants into surface water. TCE and perchlorate isoconcentration maps for the shallow and intermediate zones, based on 2007 data, are shown on Figures E3-1 through E3-4 (presented in Appendix E3) (Shaw 2010a). Based on data shown, the figures indicate that the 100 μg/L isoconcentration lines for TCE and perchlorate potentially extend to Harrison Bayou, although there have been no surface water exceedances during this reporting period indicating no unacceptable impacts to surface water.

Graphical representation of trend analysis is presented in Figures E4-1 through E4-8 (presented in Appendix E4). The data from selected wells and various sampling events are presented in Tables 4-6 through 4-9.

As indicated on Figures E4-1 and E4-2, there is considerable fluctuation in TCE concentrations for the time period plotted. Fluctuations were also observed for perchlorate concentrations in both the shallow and intermediate zone groundwater (Figures E4-5 and E4-6). These fluctuations could be attributable to the presence of finer-grained soils, period of higher than normal precipitation events, and proximity of the monitoring well location close to an extraction well. Extraction well perchlorate concentrations are presented in Table 4-7.

Table 4-6: TCE Concentrations (µg/L) in Extraction Wells

Sampling Date	Shallow Zone Monitoring				Intermediate Zone			
	16EW01	16EW02	16EW03	16EW04	16EW05	16EW06	16EW07	16EW08
2001	24,000	18,000	21,000	20,000	24,000	21,000	13,000	20,000
2003	13,800	108,000	9,250	3,760	5,200	3,150	69.5	30.3
2004	8,120	85,000	13,000	2,220	3,310	2,240	75.8	15.1
2006	16,000D	60,000D	31,000D	17,000D	5,600D	1,900D	84	12
2007	14,000	77,000	26,000	35,000	2,500	2,500	70	300
2009	10,600	131,000	77,400	40,700	9,400	536	6,040	4,870
2010	68.1	102,000	44,900	758	15.1	2,580	184	39.8
2011	36.4	68,000	30,500	20,600	501	8,330	356	196
2012	380	33,400	31,400	53,500	7,130	6,370	304	122

Sources: 2001, 2006 data taken from second Five-Year Review (Shaw 2008). 2003, 2004, and 2007 data taken from FS Addendum (Shaw 2010a). All other data from AECOM project database.
Notes:
µg/L micrograms per liter
D denotes secondary dilution (Shaw 2008)

Table 4-7: Perchlorate Concentrations (µg/L) in Extraction Wells

Sampling Date	Shallow Zone Monitoring				Intermediate Zone			
	16EW01	16EW02	16EW03	16EW04	16EW05	16EW06	16EW07	16EW08
2001	610	467	512	446	486	323	387	486
2003	74.1	86.1	148	53.9	1240	ND(1.45)	10.2	ND(1.45)
2004	424	95.8	78.7	42.3	890	125	148	136
2006	57	17	57	78	1,000	250	77	66
2007	500	50	55	13	500	80	30	75
2009	910	39	ND(2.2)	ND(2.2)	710	270	490	51
2010	770	38	ND(3.0)	ND(1.5)	4.4	30	ND(3.0)	ND(1.2)
2011	729	29.3	6.54	0.518	252	123	1.85	0.116
2012	1050	151	0.139	0.165	529	76.4	ND(0.2)	ND(0.2)

Sources: 2001, 2006 data taken from second Five-Year Review (Shaw 2008). 2003, 2004, and 2007 data taken from FS Addendum (Shaw 2010a). All other data taken from AECOM project database.
Notes:
µg/L micrograms per liter
ND not detected; values within parentheses denote detection limit

Monitoring data for select wells close to the source (landfill) and downgradient of the extraction system are summarized in Table 4-8. TCE concentrations in groundwater close to the landfill boundary initially decreased but more recently have increased. A general decline in groundwater TCE concentration is observed at wells 16WW22 and 16WW29; however, a trend of increasing TCE concentration is observed at 16WW12 (Figures E4-3 and E4-4). Perchlorate concentrations (Table 4-9) in groundwater have declined at wells 16WW22 and 16WW30 but increased at wells 16WW12 and 16WW29 (Figures E4-7 and E4-8). This could be due to the reduced efficiency of the extraction system that may not have been providing adequate hydraulic containment. As of January 2013, all extractions wells have been repaired or replaced. Relatively high concentrations of TCE downgradient of the cap were detected at 16EW02 (33,400 µg/L), 16EW03 (31,400 µg/L) and 16EW04 (53,500 µg/L) during December 2012 sampling event, suggesting that a continuing source may be present unless high concentrations of TCE had already migrated to the aquifer prior to capping. The continuing source could be present in the form of dense non-aqueous phase liquid (DNAPL) and further investigation is recommended to update the CSM and support final remedy. The presence of DNAPL, if any would likely inhibit ISB due to high concentrations of TCE and could limit the overall effectiveness of the final remedy to meet cleanup goals.

Table 4-8: TCE Concentrations (µg/L) in the Shallow Zone Monitoring Wells

Sampling Date	Close Proximity to Landfill Boundary (NE)		Downgradient of Extraction System			
	16WW16	16WW36	16WW12	16WW22	16WW30	16WW32[1]
Jun-95	20900	NA	1390	NA	NA	NA
Feb-96	NA	NA	NA	NA	NA	NA
Mar-96	NA	NA	NA	NA	NA	NA
Oct-97	25000	11000	7500	2700	36	1.1
Jan-98	19000	8600	5100	4300	9.3	NA
Jun-98	15000	8900	7100	NA	11	NA
May-00	12000	7200	NA	NA	NA	NA
Oct-00	13000	12400	NA	NA	NA	NA
Mar-03	19600	16000	1940	240	4.76	ND(0.36)
Feb-04	15600	37800	5520	252	13.8	ND(0.36)
Dec-04	15000	70600	1100	126	6.05	ND(0.36)
Jun-07	8830	29200	3840	119	20.1	NA
Oct-07	NA	NA	4500	NA	NA	NA
Mar-09	18900	29300	NA	NA	NA	ND(0.25)

Notes:
[1]Well 16WW32 lies cross gradient of the extraction system
µg/L micrograms per liter
NA not analyzed
ND not detected; values within parentheses denote detection limit
TCE trichloroethene

Table 4-9: Perchlorate Concentrations (µg/L) in the Shallow Zone Monitoring Wells

Year	Monitoring Wells Close Proximity to Landfill Boundary (NE)		Downgradient of Extraction System			
	16WW16	16WW36	16WW12	16WW22	16WW30	16WW32
May-00	515	69.7	64	65.9	NA	NA
Oct-00	861	ND(3.4)	200	97	ND(0.85)	58
Feb-01	1400	30	280	507	NA	ND(0.85)
Mar-02	NA	NA	2430	38.4	553	ND(9.58)
Sep-02	NA	NA	747	750	ND(29)	ND(4)
Mar-03	883	91	73	20.5	ND(1.45)	ND(4)
Feb-04	818	101	86	43.9	43.9	10.2
Dec-04	615	57.7	74.6	50.3	0.0699	ND(0.05)
Jun-07	278	441	322	5.0	ND(1)	ND(0.50)
Oct-07	NA	NA	5990	NA	NA	NA
Mar-09	240	5.5	NA	NA	NA	0.55

Notes:
µg/L migrogram per liter
NA not analyzed
ND not detected

The main concern at LHAAP-16 is the potential of groundwater to transport contaminants into Harrison Bayou. Surface water sampling of Harrison Bayou is being conducted at HBW-1, located 100 feet northeast of monitoring well 16WW12 (Figure 4-1). Since June 2002, TCE concentrations were above 5 µg/L only in the summer of 2003 with a maximum of 74.2 µg/L in August, 2003. At other times, the TCE concentrations ranged from 1.25 µg/L to non-detect. There have been no exceedances during this reporting period. The highest perchlorate concentration of 122 µg/L was detected in 2007 but the concentrations have declined since then, ranging between 0.1 and 4 µg/L.

4.9.5 Site Inspection

Representatives of the USEPA, the TCEQ, U.S. Army, and AECOM carried out inspection at LHAAP-16 on January 8, 2013. The purpose of the inspection was to objectively assess the operations and effectiveness of the remedy (landfill cap and LUCs) implemented at this site. During the site visit, a Five-Year Review SI checklist was completed to document the status of LHAAP-16 (Appendix E5). Weather was clear and the temperature ranged between high 50s and low 60s (°F) at the time of the SI. Photographs of the site visit are presented in Appendix E6.

A summary of the SI is as follows. LHAAP-16 is fenced with warning signs posted along the fence line. The vegetative cover was observed to be in good condition and well-maintained through routine mowing, except for a few spots affected by minor subsidence and erosion. Shallow subsidence, approximating 0.5 feet, was observed to be present in several locations. These spots were flagged for backfilling and regrading by the current site contractor during this SI. The fencing remains intact with no noticeable breeches in barbed wire. Well-head locks are in good condition. Minor surface erosion with sparse vegetation was observed in a number of locations. This was addressed by repairing and spreading grass seed over the eroded areas and one bare spot on the cap in July 2013. Minor signs of burrowing animals were observed on the east and central area which were filled in as part of the July 2013 soil addition. No excessive cracking or desiccation was observed for the landfill cap. No change in land or groundwater use was observed at the site. The historical issue of silting of piezometers will be addressed as part of the Remedial Design. Onsite documents and records were verified for completeness including as-built drawings, maintenance logs, site-specific HASP, daily access/security logs, and compliance records, are up-to-date and are in satisfactory condition. No significant issues were identified regarding the cap condition or maintenance, fences, and site security.

4.9.6 Interview Summary

The completed Interview Summary Forms are presented in Appendix I.

4.10 Technical Assessment

4.10.1 Question A: Is the remedy functioning as intended by the decision documents?

Answer: Yes (pertains to final cap remedy - components of the final groundwater remedy are in the decision phase and not addressed in this five year review)

Element	Assessment
A Performance	This assessment pertains to part of the final remedy consisting of cap maintenance and interim remedy consisting of cap construction, maintenance/repair and LUCs. The components of the final remedy, such as enhanced LUCs, *in-situ* bioremediation, biobarriers, periodic sampling of piezometers, the clean-up of silting wells, and MNA are in the decision phase and not part of this review. In accordance with the IRA ROD (USACE 1995), the cap construction was completed in 1999. To date, the cap has been providing long-term protection by minimizing vertical infiltration of water into the landfill. The cap controls only vertical infiltration and is therefore not effective in limiting mobility of COCs that are already present in the groundwater plume or if a continuing source such as DNAPL is present outside the cap. If DNAPL continues to exist in the waste/soil, then the cap may be very effective in limiting the vertical migration to groundwater. Monitoring well 16WW16 (in close proximity to the landfill boundary) indicates an elevated TCE concentration (18,900 μg/L) as of March 2009. Based on October 2007 data, TCE concentrations appear to be increasing at a downgradient well 16WW12. There have been no exceedances in surface water for perchlorate or TCE during this reporting period. These issues will be addressed by implementation of the anticipated final remedy consisting of enhanced *in-situ* bioremediation in the most contaminated area combined with a downgradient biobarrier. This would also allow shutdown of the extraction system as specified in the Draft Final ROD (Shaw 2011). LUCs are functioning to mitigate potential risks to human health and the environment by cutting off exposure to the source material.
System Operations/O&M	The cap is functioning as designed and needs only routine maintenance. The cap is maintained and inspected in accordance with the RCRA requirements and is carried out under the LHAAP-18/24 O&M plan. The Site 16 O&M activities will be provided in a separate written O&M Plan for maintenance of the cap and is estimated to be in place by summer of 2013..

Element	Assessment
Cost of Systems Operations/O&M	The O&M cost for LHAAP-16 is combined with that of LHAAP-12 and LHAAP-18/24. Based on 2007-2011 data, the incurred costs for these three sites are stable or decreasing compared to the estimated cost with the exception of LHAAP-18/24 which requires periodic optimization or capital equipment replacement requiring additional funds.
Opportunities for Optimization	None.
Early Indicator of Potential Remedy Failure	Some minor erosion issues and growth of pine trees were observed in the past. Vegetation growth on the landfill cap has been adequately addressed. Minor erosion was observed during the January 2013 SI. No indicators of potential failure were observed during this Five-Year Review.
Implementation of Institutional Controls and Other Measures	The January 2013 SI at LHAAP-16 indicated that fencing was intact and in good condition. A few signs were observed to be missing. Overall, the site is consistent with LUCs mandated by the IRA ROD. In addition, no water production wells have been installed at the site. The property is under the jurisdiction of the U.S. Army and would later be transferred to USFWS only after completion of the final remedy.

4.10.2 Question B: Are the assumptions used at the time of remedy selection still valid?

Answer: Yes

Element	Assessment
Changes in Standards and TBC Requirements	Regulatory requirements were considered in the selection of the IRA. The ARARs developed for the LHAAP-16, Old Landfill are evaluated in Appendix C. • Chemical-Specific ARARs: Chemical-specific requirements provide health- or risk-based concentration limits or discharge limitations in various environmental media for specific hazardous substances, pollutants, or contaminants. No chemical-specific ARARs were identified in the IRA. • Location-Specific ARARs: Location-specific ARARs are restrictions on remedial activities solely based on the location of the remedial activity, such as certain environmentally sensitive areas. Table C-1 lists the location-specific ARARs. • Action-Specific ARARs: Action-specific ARARs are usually technology or activity-based requirements or limitations or actions taken with respect to hazardous waste sites. Action-specific ARARs are listed in Table C-2. Review of ARARSs for sites covered in this Five-Year Review did not identify any new requirements.
Changes in Exposure Pathways and Land Use	LHAAP is an inactive, government-owned, formerly contractor-operated and -maintained Department of Defense facility located in central east Texas. The capped LHAAP-16 Landfill was used from the 1940s to the 1980s for the disposal of solid and industrial wastes. A groundwater extraction system that is not part of the IRA remedy has been operating for over 12 years to prevent the groundwater plume from migrating to the adjacent Harrison Bayou. The land on which this site is located is intended for transfer to the USFWS for incorporation into the Caddo Lake National Wildlife Refuge. Future anticipated use is consistent with an industrial/recreational level of exposure. No change in land use has occurred at LHAAP-16 since the IRA was implemented. No significant change in exposure pathways has occurred at the site. Both human and ecological receptor populations are also the same.
Changes in Risk Assessment Methodologies	The risk assessment was not completed at the time of the IRA. The Final ROD will address risk assessment.
Toxic Remedy Byproducts	No remedy byproducts have been identified to consider in this assessment.
New Contaminants and Contaminant Sources	No new contaminant sources have been identified.
Expected Progress Toward Meeting RAOs	No changes in the physical condition of the LHAAP-16 landfill have occurred that would affect the protectiveness of the remedy.

4.10.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy

Answer: None identified for the assessment of the landfill cap.

4.11 Issues

4.11.1 Issues Identified during the Technical Assessment and Other Five-Year Review Activities

Issues identified during the Five-Year Reviews are listed below:

First Five-Year Review	• Groundwater monitoring not conducted regularly • Need O&M Plan • Ecological Risk Assessment not complete • Evaluate the hydrogeologic effectiveness of the groundwater extraction system • Groundwater model in RI/FS should provide modeling of perchlorate and possibly other contaminants • Steel covers off of housing at extraction wells
Second Five-Year Review	• Some minor erosion and unwanted vegetation on landfill cap • Age and condition of piezometers • Need O&M Plan • Groundwater monitoring (chemical sampling and water levels) not conducted regularly or documented properly.
Current Technical Assessment (Third Five-Year Review)	• Separate O&M Plan for cap maintenance from LHAAP-18/24 O&M Plan • GWTP Quarterly Evaluation Reports should include periodic updated groundwater gradient map.

4.11.2 Determination of Whether Issues Affect Current or Future Protectiveness

Most of the issues identified during the previous Five-Year Reviews have been addressed per recommended follow-up actions. Issues that remain unaddressed are incorporated as issues under this review (Section 4.12) and do not affect current or future protectiveness of the IRA or the final remedy not yet in place.

The issues identified during this Five-Year Review do not affect current protectiveness of the remedy in place (landfill cap and LUCs); future protectiveness is being address by the remedy specified in the Draft Final ROD (Shaw 2011), which is under dispute by EPA.

4.11.3 Unresolved Issues

None.

4.12 Recommendations and Follow-up Actions

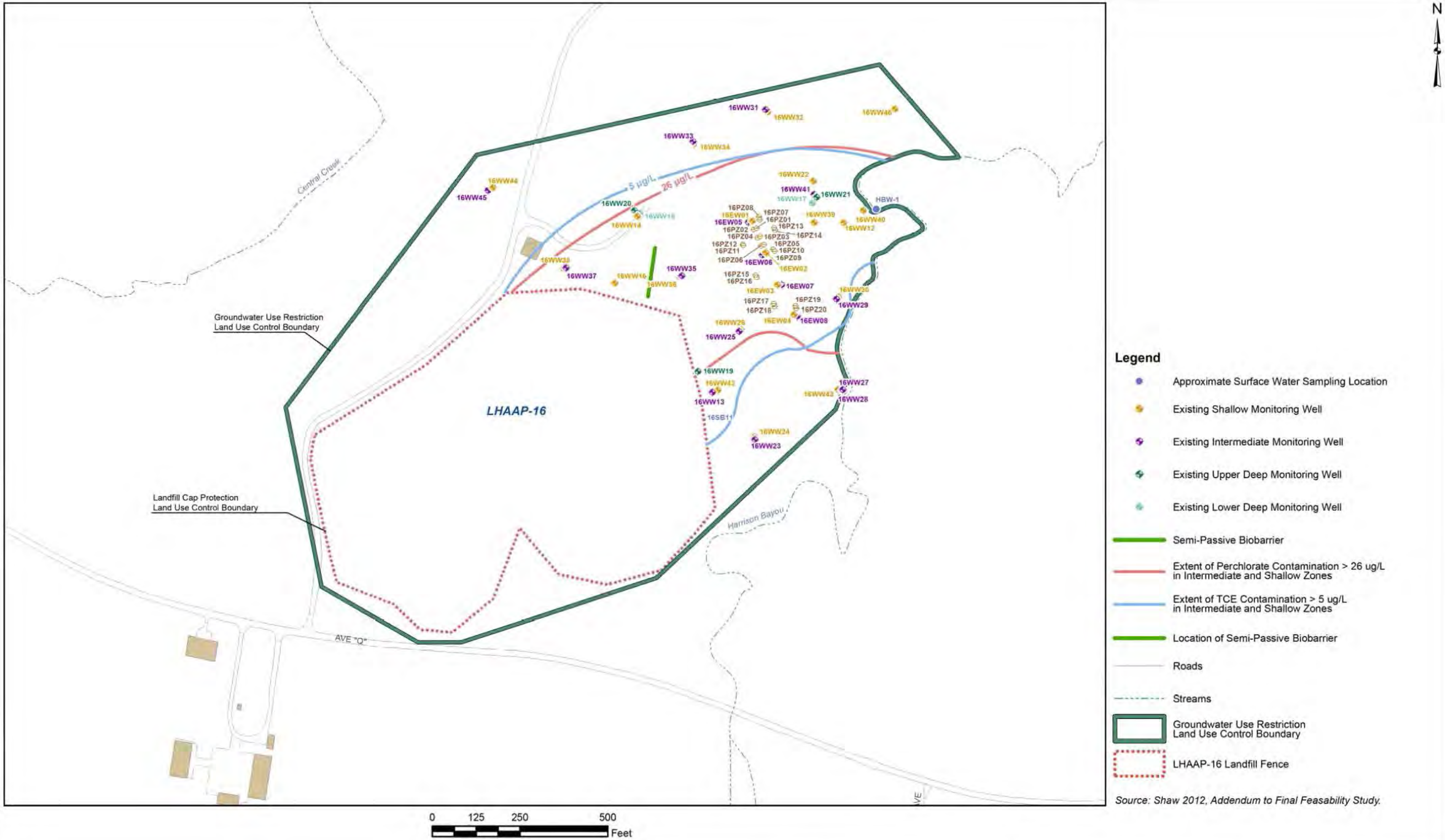
Based on this Five-Year Review, the issues, recommendations, and follow-up actions are presented in Table 4-11.

4.13 Protectiveness Summary

The IRA remedy at LHAAP-16 currently protects human health and the environment because the cap and an extraction system, which is part of a TS, combined with LUCs prevent direct exposure pathway to landfill material, reduce contaminant transport and mass of contaminants in the groundwater. Additionally the groundwater monitoring program assures prevention of exposure. The final remedy documented in the Draft Final ROD inclusive of the IRA cap, *In-situ* bioremediation/biobarriers, and additional LUCs such as groundwater use restrictions is expected to be protective of human health and the environment upon completion. *In-situ* bioremediation/biobarriers in the final remedy will mitigate the potential for contaminants to seep into Harrison Bayou surface water at unacceptable levels.

Table 4-10: Recommendations/Follow-up Actions for LHAAP-16

Issue	Recommendation/Follow-up Action	Party Responsible	Oversight Agency	Milestone Date	Affects Current Protectiveness?	Affects Future Protectiveness?
Need separate O&M plan for cap	Prepare O&M Plan for the landfill cap	USACE	State/USEPA	July 2014	No	No
Minor erosion of the landfill cap	Repair erosion. .	USACE	State/ USEPA	July 2014	No	Yes
Groundwater monitoring (chemical sampling and water levels)	This data will be reported in the quarterly GWTP Evaluation Reports to include an updated groundwater gradient map	USACE	State/USEPA	April 2014	No	No
Relatively high concentrations of TCE downgradient of the cap were detected at 16EW02 (33,400 μg/L), 16EW03 (31,400 μg/L) and 16EW04 (53,500 μg/L) during December 2012 sampling event, suggesting that a continuing source may be present unless high concentrations of TCE had already migrated to the aquifer prior to capping.	Implement Final Remedy once ROD is approved. The final remedy will address continuing sources.	USACE	State/USEPA	Remedial Action Construction completion date	No	Yes



AECOM

Figure 4-1
Extent of Groundwater Contamination and Well Locations
LHAAP-16 Five Year Review
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012

5 LHAAP 18/24

5.1 Site Chronology

Sites LHAAP-18 and LHAAP-24 consist of an approximately three-acre former UEP, LHAAP-24, that was located within the approximately 34.5 acre former BG3, LHAAP-18). LHAAP-24 is located within the most northern quarter of the former BG3 site. Significant events relevant to combined site LHAAP-18/24 are presented in Table 5-1. This table provides a chronology of events from the first known operations, through the IRA ROD (USACE 1995) and the previous Five Year Review (Shaw 2008), to the present.

Table 5-1: Chronology of Site Events for LHAAP-18/24

Event	Date[a]
BG3 begins operation for disposal of wastes associated with pyrotechnics, explosives, and propellant production.	1955
UEP constructed for disposal of manufacturing plant wastewaters.	1963
AEHA Water Quality Special Study first identifies contamination at the UEP (Site 24) within the boundaries of BG3 (Site 18).	August 2 - 10, 1976
Land Disposal Study No. 38-26-0104-81, LHAAP: AEHA installs thirteen monitoring wells and finds groundwater contamination at UEP (Site 24) in BG3 (Site 18).	January 23 - February 8, 1980
EPS installs nine monitoring wells and samples twenty-two monitoring wells.	1982
Hazardous Waste Management Special Study No. 39-26-147-83, DARCOM Open Burning/Open Detonation Grounds Evaluation.	September 1, 1983
Waste disposal terminated at UEP.	June 1, 1984
EPS collects groundwater samples from three wells.	1987
Closure Report for UEP.	June 1, 1986
RFA reviewed all sites at LHAAP and assigned identification numbers that are currently in use.	April 8, 1988
Compliance groundwater monitoring wells installed by USACE at LHAAP 18 & 24 as a RCRA Facility Investigation (RFI).	1989
LHAAP placed on NPL	August 29, 1990
LHAAP, Texas Water Commission (later TNRCC and now TCEQ), and USEPA enter into a CERCLA Section 120 Agreement for remedial activities at LHAAP, referred to as the FFA	December 30, 1991
RCRA Part B Permit signed.	February, 1992
IRA Design Initiated for LHAAP-18/24.	1994
Interim Risk Assessment for BG3 and UEP (LHAAP-18/24).	January 18, 1994
Final ROD for Early IRA at BG3 (LHAAP-18/24).	May 12, 1995
Phase II Field Investigation by Sverdrup installed eighteen additional monitoring wells and collected soil, sediment, groundwater, and surface water samples.	1995
Start of construction on extraction and treatment system for metals and organic contamination at LHAAP-18/24.	March 1995
Final WP for Phase III IRA at BG3.	January 3, 1996

Event	Date[a]
IRA construction start date.	October 25, 1996
GWTP approved and began operating with approximately 5,000 linear feet of ICT to control migration of contaminated groundwater.	January 1997
Start date for the excavation of 37,840 cubic yards of soil and treatment of the soil in low temperature thermal desorption (LTTD) unit.	February 12, 1997
Proof of Performance test conducted for soil treatment plant	February 13-15, 1997
Proof of Performance test conducted at GWTP.	March 24, 1998
Phase III Field Investigation by Sverdrup collected groundwater, sediment, and surface water samples.	1998
Closure of burning cages at BG3.	1998
Perchlorate discovered in groundwater at LHAAP-18/24.	April 1999
IRA construction completion date.	August 31, 1999
U.S. Army, USEPA, and TNRCC (now TCEQ) agree to establish discharge limits for perchlorate in effluent from the GWTP.	December 2, 1999
Second Quarter Data Summary for Perchlorate Investigation.	March 2001
Fluidized Bed Reactor (FBR) for treatment of perchlorate goes online at GWTP.	April 2001
Final RI Report for LHAAP-18/24.	April 2001
Five-Year Review for Sites 18 & 24 (BG3), Site 16 (Old Landfill), and Site 12 (Sanitary Landfill).	August 2002
Final Group 2 Sites Baseline Human Health and Screening Ecological Risk Assessment (Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake).	August 2002
Final WP, Groundwater Data Gaps Investigation, Groups 2 and 4.	February 2004
Environmental Site Assessment, Phase I and II Report, Final.	February 2005
STEP issues Final Plant-Wide Perchlorate Investigation for LHAAP. For perchlorate at LHAAP-18/24, the report concludes that further remediation of soil is unnecessary, but that groundwater monitoring should continue until "further remedial measures are implemented."	April 2005
TCEQ approves use of irrigation system at LHAAP-18/24 as an alternative to Harrison Bayou for discharge of effluent from the GWTP during dry periods.	August 26, 2005
Draft Final BERA was submitted to regulatory agencies for approval.	March 2007
Data Gaps Investigation Report	April 2007
Sampling and Analysis Plan (SAP) for the GWTP and well fields submitted by Shaw	July 19, 2007
Pilot Study Implementation Plan for the GWTP and well fields submitted by Shaw	September 13, 2007
Injection in ICTs-6 and 9 began.[b]	September 17, 2007
Injection Sumps 1, 3, 5, 10 and 12A deactivated.	September 2007
Final BERA approved.	November 2007
Final Second Five-Year Review Report for LHAAP-12, LHAAP-16 and LHAAP-18/24.	October 2008
Start withdrawals, vertical extraction Well EW-1 and converted Monitoring Well 18WW17 for groundwater withdraws during high water.[d]	October 2008
Final Explanation of Significant Differences (ESD) for LHAAP-18/24 submitted by USACE.	August 2010

Event	Date[a]
Approval Letter from TCEQ for changes to interim remedy presented in ESD.	February 12, 2010
Irrigation Sprinklers installed in Eastern Section BG3 to help induce groundwater capture. [d]	May 2007
GWTP Inoperable Scrubber Unit, Injection in ICTs-6 and 9 ended .[c d]	May 21, 2012
ICT 12A restarted, withdrawing groundwater. [d]	December 2012

[a] All documents and events listed prior to April, 2007 taken from Shaw (Shaw 2008, Table 2-3).Remaining documents and events listed after April, 2007 are from the U.S. Army Administrative Record.
[b] (Shaw 2008).
[c] (Shaw 2012b).
[d] Telephone Interview with Scott Beesinger, GWTP Operations Manager, January 24, 2012.

5.2 History of Contamination

Figure 2-1 shows the location of LHAAP 18/24. As early as 1955, the former BG3 area was used for the treatment, storage, and disposal of pyrotechnic and combustible solvent wastes by open burning, incineration, evaporation and burial. Waste management units included the UEP, open burning pits, stockpiles of solvent-soaked sawdust, and suspected burial pits. The UEP began operating in 1963 as a holding pond to store wastes from the washout of rocket motor casings, and in 1973 began receiving wash-water containing solvent residues and solids from pyrotechnic material preparation and mixing. These residues and solids commonly contained metallic cations (aluminum, barium, cadmium, chromium, iron, lead, magnesium, sodium, strontium, and zinc), nonmetallic anions (nitrite, nitrate, and phosphate), arsenic, and organic solvents (acetone, ethyl alcohol, methyl ethyl ketone, MC, TCE, and toluene). Sawdust soaked with MC and other solvents, used to clean and scour illuminant mixers, was stockpiled along the southern berm of the UEP and burned in trenches in the western portion of BG3. An Air Curtain Destructor was built in 1979 in the western corner for burning explosive-contaminated wastes. Use of the burn pits, trenches, and the UEP were all reportedly discontinued in 1984. When groundwater beneath the site was found contaminated, the UEP was closed in 1986 by removing the waste and capping. To accommodate Intermediate-Range Nuclear Forces (INF) Treaty activities, a cage for the open burning of Pershing II missile motors operated from 1989 to 1993 (USACE 1995). These historical features are presented in Figure 5-4.

5.3 Initial Response

Waste removal and RAs at LHAAP-18/24 began after the May 1995 IRA ROD for soil remediation and groundwater extraction/treatment was signed (Shaw 2008). From February 22 through December 10, 1997, extensive soil excavation and treatment was conducted. Soil removal included 30,000 cubic yards of source material, 1,029 cubic yards of material from the interception collection trenches (ICTs), 105 cubic yards of material from the burning cages, and 1,157 cubic yards of material from storage and treatment area floors. Perimeter air monitoring was conducted during the operations and the treated soils were used as fill at the LHAAP-12 and LHAAP-16 landfills (Shaw 2008). The GWTP, including approximately 5,000 feet of ICT began operating in January 1997, and a fluidized bed reactor (FBR) began treating perchlorate at the GWTP in April 2001 (Shaw 2008). Figure 5-5 shows the LHAAP-18/24 area with the layout of the ICTs and the location of the GWTP.

Soil borings and monitoring wells with limited sampling were first installed at the site in 1980 (AEHA 1980). In 1989, there were approximately 25 monitoring wells located on and downgradient of the site (USACE 1989). In 1990, LHAAP was placed on the NPL and in 1991 the U.S. Army, USEPA, and the State of Texas entered into a FFA designating LHAAP as a "fence to fence" site. LHAAP-18/24 was included in the FFA as a solid waste management unit (Shaw 2008).

5.4 Basis for Taking Action

As stated in the IRA ROD, action was necessary to mitigate potential risks posed by elevated concentrations of chlorinated solvents and heavy metals in shallow groundwater and the buried source material at the site. Previous investigations showed extensive soil and groundwater contamination, although a formal risk assessment had not been completed for the site when the IRA ROD was signed (Shaw 2008).

The contaminants at the site are chlorinated solvents and metals. Prior to the IRA, concentrations of MC and TCE were higher in groundwater, and the plumes were presumably expanding. Since the site is located east of Harrison Bayou (which eventually discharges into Caddo Lake), and a portion of the site is within the 100-year flood plain, there were concerns about migration of contaminants from groundwater to surface water. The remedial objectives for the IRA were to eliminate or minimize the potential for exposure to human and ecological receptors. The interim remedy was selected to achieve this by reducing or preventing further migration of contaminants into deeper groundwater zones and possibly surface water bodies (USACE 1995). Groundwater monitoring well sampling criteria changed in late 2006 when the U.S. Army, the USEPA, and the TCEQ agreed that only 15 of the previous 47 monitoring wells were necessary for monitoring contaminants on a semi-annual basis (Shaw 2006; Shaw 2007e).

5.5 Remedial Actions

5.5.1 Regulatory Basis for Action

The USEPA (Region 6) and TCEQ are the regulatory agencies providing technical support, project review, comment, and oversight of the LHAAP cleanup program implemented by the lead agency, the U.S. Army. The IRA ROD for LHAAP-18/24 addressed both soil and groundwater contamination (Shaw 2008). The selected remedy for addressing the site contaminants and meeting the remedial objectives of the IRA was a combination of soil removal/treatment and groundwater extraction and treatment. The U.S. Army issued the IRA ROD on April 18, 1995, which was approved by the USEPA on May 12, 1995 (USACE 1995). . These requirements were presented in the previous Five-Year Review (Table 4-2 of that document) and deal mostly with reporting and ongoing submittals (Shaw 2008). A Final ROD and selected remedy have not been issued by the U.S. Army for LHAAP-18/24. LUCs will also be evaluated as a component of the final remedy.

5.5.2 Remedial Action Objectives

The RAOs developed for the IRA were to eliminate or minimize the potential for exposure to human and ecological receptors. The interim remedy was selected to achieve this by reducing and/or preventing further migration of contaminants into deeper groundwater zones and possibly surface water bodies (USACE 1995). The IRA construction completion date was August 31, 1999 (Shaw 2008).

5.5.3 Remedy Description

The interim remedy consists of:

- Extraction of shallow groundwater followed by treatment using metal precipitation, air stripping, and off-gas treatment for VOCs. After treatment, the effluent is discharged to Harrison Bayou, to BG3 by sprinkler system, or to a holding pond for temporary storage
- Excavation of soil source material and treatment using low temperature thermal desorption (LTTD) and off-gas treatment for VOCs. Treated soils were used as fill at the LHAAP-012 and LHAAP-016 landfills
- Five-year reviews

Further details on the treatment systems are presented in Section 5.5.4.1. Differences in the treatment system from that specified in the IRA ROD are discussed in the 2008 Five-Year Review (Shaw 2008) and the Explanation of Significant Differences (ESD) document (USACE 2010b).

5.5.4 Remedy Implementation

5.5.4.1 Groundwater Extraction and Treatment

The GWTP and approximately 5,000 feet of ICTs began operating in January 1997. These elements of the IRA are shown on Figure 5-5. Details of the extraction component of the remedial system include 14 ICTs ranging in length from approximately 100-1,300 feet, located within and around three sides of the former burning ground. The trenches extend approximately 25-55 feet deep to the confining clay layer of the shallow groundwater zone. After construction, piezometers were installed to evaluate ICT effectiveness. Water levels within the trenches are controlled using water level probes, set at various levels to activate or deactivate the twenty-eight sump pumps. These maximize groundwater capture and remove the groundwater from the ICT sections through dual wall containment piping, which leads to a 300,000-gallon influent equalization holding tank at the GWTP (Shaw 2008).

The contaminated groundwater from the sumps is treated at the GWTP and discharged to Harrison Bayou, per the guidelines presented in the 1995 IRA ROD. The rate at which treated water can be discharged to Harrison Bayou depends on the flow in the bayou. Historically there have been extended periods when the lack of flow in Harrison Bayou does not allow the discharge of treated water. During these frequent periods, the treated water is either allowed to infiltrate via the irrigation system sprinklers located on the east side of LHAAP-18/24, or diverted to the INF lined holding pond for temporary storage. During extended dry periods, the INF pond was frequently near maximum capacity; thus sprinklers were installed in May 2007 to help induce groundwater capture (Shaw 2008).

5.5.4.2 Excavation and Treatment of Source Material

From February 22 through December 10, 1997, extensive soil excavation and treatment was conducted. Prior to the excavation activities and after initial mobilization and set-up, soil dewatering and storage pads were constructed. Details regarding system set-up are presented in the Final General WP IRA for BG3 (Dow Environmental, Inc. [Dow] 1995) and performance testing of the LTTD soil treatment system (February 13 to 15, 1997) is presented in the LTTD Proof of Performance Test Results document (Radian 1998).

Soil, including 30,000 cubic yards of source material, 1,029 cubic yards of material from the ICT trenches, 105 cubic yards of material from the burning cages, and 1,157 cubic yards of material from storage and treatment area floors was removed. Treated soils were used as fill at the LHAAP-12 and LHAAP-16 landfills. Confirmation soil sampling was reportedly conducted, as well as drilling of 20 soil borings to investigate the potential presence of additional source material. The site was then restored by backfilling the excavations with clean fill, repairing utility lines, etc. (Shaw 2008).

5.6 Compliance Monitoring

Compliance monitoring at site LHAAP-18/24 consists of inspections; air, influent, and effluent monitoring at the GWTP; monitoring well and piezometer groundwater elevation surveys; monitoring well sampling; and the Five-Year Reviews. All the sampling requirements from the IRA ROD, General WP for IRA (Dow 1995), as well as regulatory approval letters and memoranda, were brought together in the 2007 SAP for the GWTP and well fields (Shaw 2007e). The relevant letters and memorandums are presented in Appendix A of that document. The scheduling, references, parameters, and test methods were presented in Table 4-4 of the 2008 Five-Year Review (Shaw 2008). Results of the GWTP monitoring over the past five-year period are presented in quarterly monitoring reports (for example, Shaw 2012b).

Historically, groundwater contaminants at the site were monitored quarterly between 1986 and 1994 and have been monitored semi-annually since 1997, with directed sampling events occasionally occurring (Shaw 2008). Based on evaluation of historical results and the monitoring well locations, the number of wells sampled was reduced from 47 to 15 in 2007 (Shaw 2008). Groundwater levels are measured monthly in the original forty-seven monitoring wells and twelve piezometers, and frequently there are additional monitoring well water levels measured. The data are maintained on-site at the GWTP and are tabulated and presented in plan-view figures, as well as time-trend graphs in monthly and quarterly reports that are submitted to the regulatory agencies. These data are used to monitor the hydraulic effectiveness of groundwater extraction and to confirm that contaminants do not discharge into Harrison Bayou at concentrations exceeding ARARs. It should be noted that the majority of groundwater contour maps presented over the past five years were generated using water levels from the shallow monitoring wells with fewer intermediate and deep groundwater contour maps produced. Contaminant concentrations in the ICTs are measured annually. Since mid-2012 as part of preparation for the final remedy, additional locations have been added to the sampling program and between 40 and 50 locations were sampled in September 2012 and February 2013.

Because contaminants remain above levels that allow for unlimited use and unrestricted exposure, Five-Year Reviews will continue to be conducted to ensure protection of human health and the environment under CERCLA §121(c), U.S. Code (U.S.C.) Title 42 §9621(c).

5.7 Systems Operations and Maintenance

The primary O&M activities at the BG3/UEP site are:

- Collection of monitoring well and piezometer water-level measurements and groundwater samples

- Maintenance, compliance monitoring, system adjustments, evaluation, and optimization of the ICT/groundwater extraction systems associated with LHAAP-18/24 and LHAAP-16
- Chemical monitoring of the ICTs and influent and effluent results
- GWTP air, influent, and effluent compliance monitoring
- Maintenance and operation of the GWTP, including all influent and effluent components
- Data compilation, records upkeep, and submittal of reports on GWTP operations and sampling results
- Maintenance all on-site equipment, including fences and signs, and routine maintenance activities (mowing, etc.), including the extraction system area and equipment at LHAAP-16

5.7.1 Treatment or Other System Processes

The GWTP is located southeast of LHAAP-18/24 along Avenue Q. The treatment processes and O&M system components were summarized in the previous Five-Year Review (Shaw 2008) as:

- Pretreatment: This step removes excessive scaling and fouling chemicals dissolved in the groundwater, as well as heavy metals (antimony, arsenic, barium, chromium, manganese, thallium, nickel, silver, selenium, and lead). These chemicals are removed through pH adjustment, polymer addition, flocculation, and precipitation. Precipitation occurs in a plate clarifier. The water is then gravity-fed to a sand filter.
- Air Stripping: Following pretreatment, an eighty-foot tall air stripper is utilized to remove volatile contaminants (PCE, TCE and daughter products, MC, chloroform, 1,2-DCE, and 1,1,2-trichloroethane) from the water. The water is fed into the top of the air stripping tower, which contains a packing material that provides the proper environment for the transfer of VOCs from the water to the air stream. An air supply of 4,600 cubic feet per minute is fed into the bottom of the air stripper and flows upward through the tower. The air vents to a catalytic oxidizer.
- Carbon Columns: Two Calgon carbon columns are utilized to polish the water that has been treated for metals and VOCs. The carbon columns are in series and each contain 10,000 pounds of carbon.
- FBR: The FBR was installed following the carbon columns at the GWTP in 2001, after perchlorate was discovered in the groundwater (STEP 2005). The FBR is a 21 foot tall by 5 foot diameter column that contains a carbon bed. The circulation of water upward through the bed fluidizes the carbon. The FBR is fed a nutrient stream and an electron donor. A biomass grows on the carbon bed and consumes perchlorate in the influent water stream. The FBR process takes place as the last treatment step in the water treatment process prior to discharge.
- Catalytic Oxidation and Vent Scrubbing: The VOCs in the air stream from the air stripper are routed to a thermal catalytic oxidizer. The VOCs are converted to carbon dioxide, water, and hydrogen chloride gases. These gases are then scrubbed using water to produce a very dilute acid stream. The dilute acid is then used in the water treatment

process for pH adjustment. The scrubber on the catalytic oxidizer malfunctioned in May 2012. An interim air monitoring plan was approved to enable operation without the Catalytic Oxidation system in September 2012 and weekly air monitoring since that time has identified that air emissions meet IRA ROD discharge criteria (Texas requirements) without treatment. An Explanation of Significant Differences is currently in-progress to remove Catalytic Oxidation from the interim remedy.

- Sludge Treatment - Sludge from pretreatment is first processed in thickeners with devolatilization. Upon thickening and devolatizing, the sludge is fed through a belt press where filter cake is generated. The filter cake is transferred to a roll-off box. When the roll-off box is full, the filter cake is shipped for disposal at a hazardous waste landfill. Land-ban requirements apply to the filter cake.

Extracted groundwater collected at the GWTP is treated to the levels established in the 1995 IRA ROD As previously mentioned, the treated water is discharged as irrigation water on BG3 (within LHAAP-18), delivered as inflow to the INF lined holding pond for temporary storage, or discharged to Harrison Bayou.

Prior to the discharge of GWTP effluent to the bayou, the flow in the stream is measured by wading and current meter measurements. The calculated discharge is then compared to chloride and sulfide concentrations from a surface water sample collected at the same time and analyzed at the GWTP. These calculations are then referenced on a graph to determine if the GWTP effluent can be discharged to the bayou. Precipitated metals are taken off-site for disposal at an approved/licensed facility by a licensed contractor.

A *Remediation System Operations Plan for Groundwater Treatment Plant and Wellfields* is maintained on-site (Shaw 2008). The plan consists of written procedures, plans, permits, records, equipment, database descriptions, etc. The plan is presently under revision and applies to both the extraction systems at LHAAP-18/24 and LHAAP-16.

Records pertaining to compliance of the GWTP, such as sampling and analysis records, and discharge flow calculations are maintained at the site and the collected data (including analytical) are maintained in an electronic database. The volume of water removed from the ICTs is measured monthly and the volumes of groundwater treated and associated concentrations are presented in monthly and quarterly reports that are also provided to the regulatory agencies. GWTP reports are provided to the U.S. Army on a weekly, monthly and quarterly basis (Beesinger, Scott, personal communication January 24, 2013 [Beesinger 2013]). These reports summarize the compliance monitoring events and operations, including the GWTP air, influent, and effluent sampling results. The GWTP monitoring is performed following the guidelines presented in the 2007 SAP (Shaw 2007e), in compliance with requirements established in the IRA ROD, and as modified in subsequent arrangements with the regulatory agencies.

The GWTP is operated by a contractor, AECOM, which has been contracted to maintain and operate the GWTP through September 30, 2017 under a Worldwide Environmental Remediation Services performance-based contract. Prior to this, O&M was conducted by different contractors:

- December 2005 to March 2012 - Shaw, Houston, TX
- June 2000 to December 2005 - CES, Karnack, TX

- Before June 2000 - Radian, Austin, TX

Prior to March 2012 for this review period two full-time and one part-time operators staffed the site. Since that time, there have been three full-time employees on-site. Support is provided by engineers and scientists from AECOM's San Antonio, TX office, other AECOM offices, and as necessary, by outside consultants and engineers.

5.7.2 System Operations and Maintenance

A significant quantity of materials are used, vendor services provided and equipment repaired or replaced as part of normal O&M for the GWTP and associated systems as summarized in quarterly GWTP reports. The system is being operated efficiently and proactively by the Army. Some deferred maintenance occurring earlier in the review period has been addressed by the Army under a new contract and O&M activities are sufficiently funded throughout the next review period.

5.7.2.1 Major Maintenance

The following presents a summary of major maintenance items completed at the GWTP:

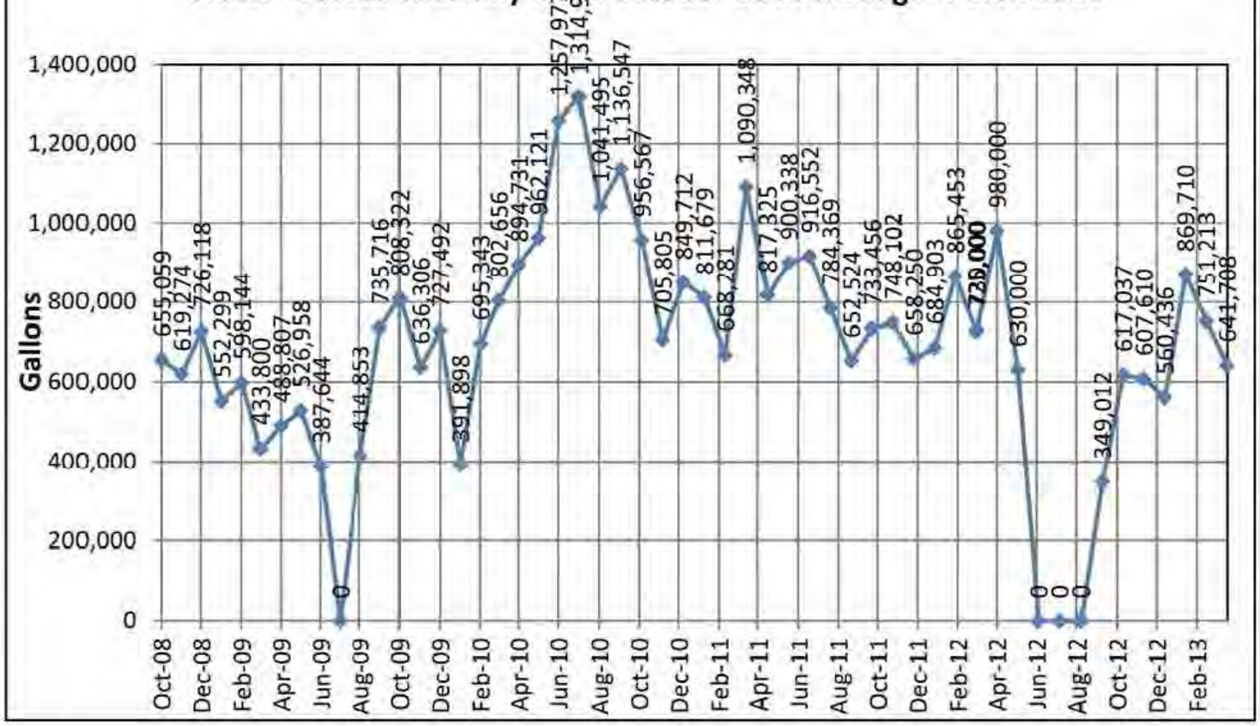
- Performed regular checks and maintenance on safety equipment.
- Collected monthly water levels from LHAAP-18/24 and LHAAP-16.
- Performed daily checks of ICTs and extraction wells leading to multiple iterative on-going maintenance activities on ICT wells, monitoring wells, and extraction wells as needed including installing new pumps, wiring, connections, or replacing or repairing components to maintain flow and improve efficiency.
- The potable water lines are flushed and repaired as needed (twice in 2012 as an example).
- Older pieces of equipment have either proactive maintenance completed or have been scheduled for replacement or were replaced during the review period
- Completed changes to programmable logic controller (PLC) program to ensure full back-up capability without service calls and also disconnected the catalytic oxidizer/quencher/scrubber system from PLC. This restored full automated-control of GWTP with full back-up capability.
- Repaired multiple broken power lines (and two power poles) during the review period due to fallen trees and multiple weather events.
- Replaced flow meters as part of materials balance analysis and optimization activities at the plant
- Replaced multiple tanks, pumps and system components

5.7.2.2 Groundwater Extracted by the GWTP and LHAAP-16 Systems

Figure 5-1 depicts the monthly total volume of groundwater treated from the ICTs and extraction wells at LHAAP-18/24 and LHAAP-16 from October 2008 through March 2013.

Items impacting extraction volumes include: ICTs 13-F and 13-G historically are low producers or non-producers due to depressed water level below the pump intakes. ICTs 1, 3, 5, 10, and 12A were shut down on 18 February 2008 as part of the Pilot Study implementation and remain non-operational with the exception of ICT 12A. This ICT was changed back to an extraction ICT in December 2012. ICTs 6 and 9 were switched to allow re-injection on 18 September 2007. Re-injection stopped in 2012 and is currently being re-evaluated. Extraction from EW-1 began on October 13, 2008.

Figure 5-1
Water Treated Monthly from October 2008 through March 2013



5.7.3 Issues Impacting Performance

5.7.3.1 Catalytic Oxidation Scrubber

The GWTP was not operational during June, July, and August 2012 after the scrubber on the catalytic oxidizer melted down due to overheating. After developing an interim air monitoring plan and obtaining concurrence from the Texas Commission on Environmental Quality (TCEQ) and the United States Environmental Protection Agency (USEPA) to operate the GWTP without use of air abatement equipment, the system was re-started with all air data results collected from three locations at the plant weekly from September 2012 onward identifying no exceedances of air emission criteria without air abatement. The formal ESD is under development to permanently remove air treatment from the interim remedy.

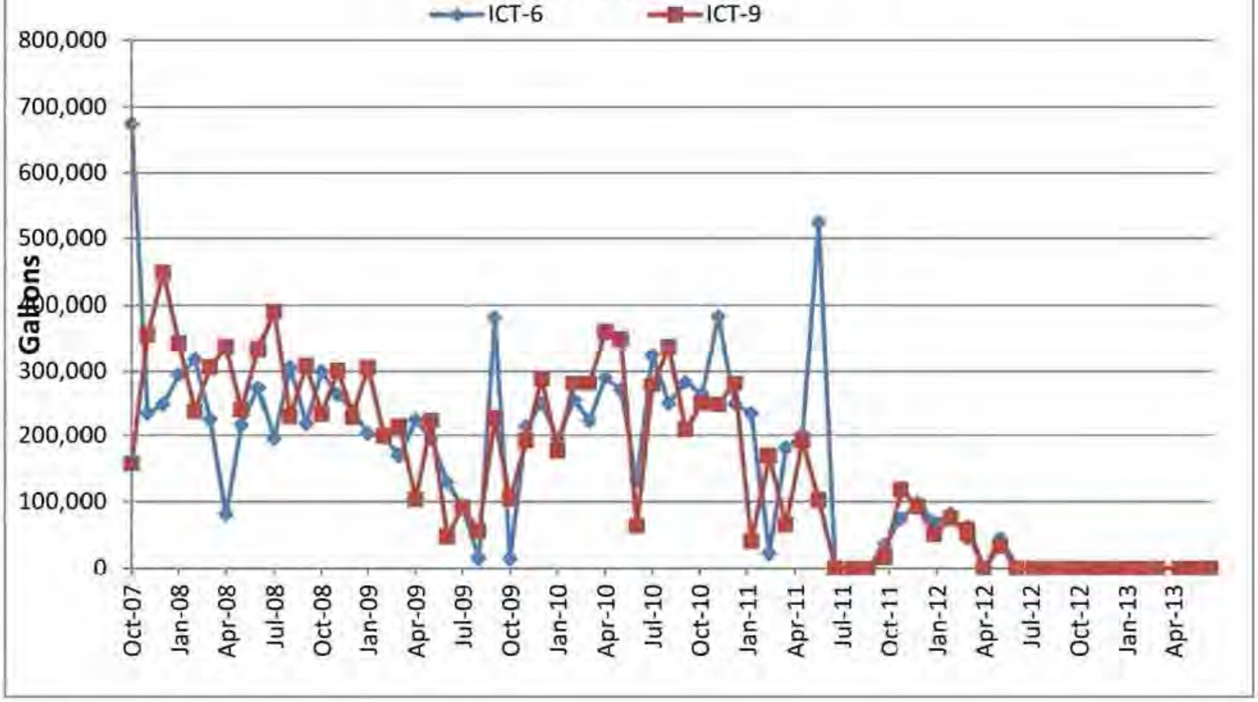
5.7.3.2 Pump and PLC Cable Severing at LHAAP-16

During the 3rd quarter 2012, groundwater extraction did not occur due to scrubber failure eon the Catalytic Oxidizer. During this time multiple pumps at LHAAP-16 were identified as fouled requiring repair or replacement and a third party severed the communication cable connecting the LHAAP-16 system to the PLC. Replacement or rebuilt pumps and a new PLC cable system were subsequently installed and extraction from LHAAP-16 began to occur in October 2012 with extraction volumes increasing steadily throughout the 4th quarter 2012.

5.7.3.3 Materials Balance

No treated water has been returned to ICTs 6 and 9 since June 2012. The water quantities discharged to LHAAP-18/24 through the injection system for each month since September 2007 are shown on Figure 5-2. The water quantities treated each month since October 2008 are shown on Figure 5-1. The difference between the volume of water processed and the water volume returned to 18/24 is associated with the change in volume stored in/released from the GWTP, inaccuracies associated with flow measurements (which has since been rectified by replacement of four critical flow meters on April 17-18, 2013), the amount of water lost with the removed metals precipitation sludge, the amount of evaporative water lost in the air stripper (which is counted in the volume processed but not the volume discharged), and the amount of water returned to TK-140 directly from rain water, filter press water, thickeners' decant water, decontamination water on the decon pad, and from any potential plant water losses captured within the containment area that might occur after the process water volume is measured.

Figure 5-2
Treated Water Injected in LHAAP-18/24 from September 2007 Through March 2013



5.7.3.4 Re-injection

Re-injection occurred through ICTs 6 and 9 throughout the review period until July, 2012. The Army is currently completing optimization activities which could result in recommendations to discontinue re-injection as a discharge alternative. This and any other recommendations from optimization activities will be documented in quarterly GWTP reports. Treated water is now returned to LHAAP-18/24 via the existing irrigation system (sprinkler heads) or discharged to Harrison Bayou based on surface water flow conditions.

5.7.4 Groundwater Treatment Plant Sampling and Analysis

As part of the GWTP operations, multiple samples from various sources or waste streams are collected and analyzed regularly for the parameters cited in the IROD and the TCEQ letter dated January 8, 2002. Besides the ROD sampling requirement, additional sample analyses are performed on the influent and effluent samples to monitor the effectiveness of the FBR process. Sampling of the effluent for VOCs, anions, perchlorate, and metals is conducted on a biweekly basis, and the results have consistently been below the discharge limits. As per the revised sampling and analysis plan (Shaw, 2007), monthly metals sampling is reported in biweekly sampling results presented in the biweekly tables in the quarterly reports. Monthly sampling for selenium and silver was continued and the results are presented in the biweekly tables. Sampling of the effluent for VOCs, anions, chemical oxygen demand, oil and grease, perchlorate, and metals is conducted on a quarterly basis and has also consistently been below the discharge limits. Additionally, weekly samples are analyzed for perchlorate. While perchlorate has occasionally exceeded its discharge criteria (6 µg/L daily average and 13 µg/L daily maximum), this has had little to no impact on protectiveness for the following reasons:

- There are relatively few excursions above the perchlorate effluent criterion. During the 2008-2012 review period, there were 792 perchlorate analyses of GWTP effluent (including QC), of which only 5 grab samples exceeded the daily average criterion of 6 µg/L and only one composite sample exceeded the daily maximum criteria of 13 µg/L. Of the six exceedances discharge was being completed to Harrison Bayou on only one of these occasions
- The purpose of the interim remedy is to contain the groundwater at LHAAP-18/24. The remedy has successfully done this, thus preventing water with very high perchlorate concentrations (e.g., groundwater at MW01 or MW03) from reaching surface water.
- When the flow in Harrison Bayou is low, the effluent is not discharged to the bayou, but is returned to the site as irrigation or discharged to the INF pond. Thus the concentration in the bayou is always much lower than the effluent concentration.

Only one exceedance was observed for composite samples, indicating that for a longer performance period (i.e., daily composite samples versus grab samples), exceedances for perchlorate in the effluent are minimal.

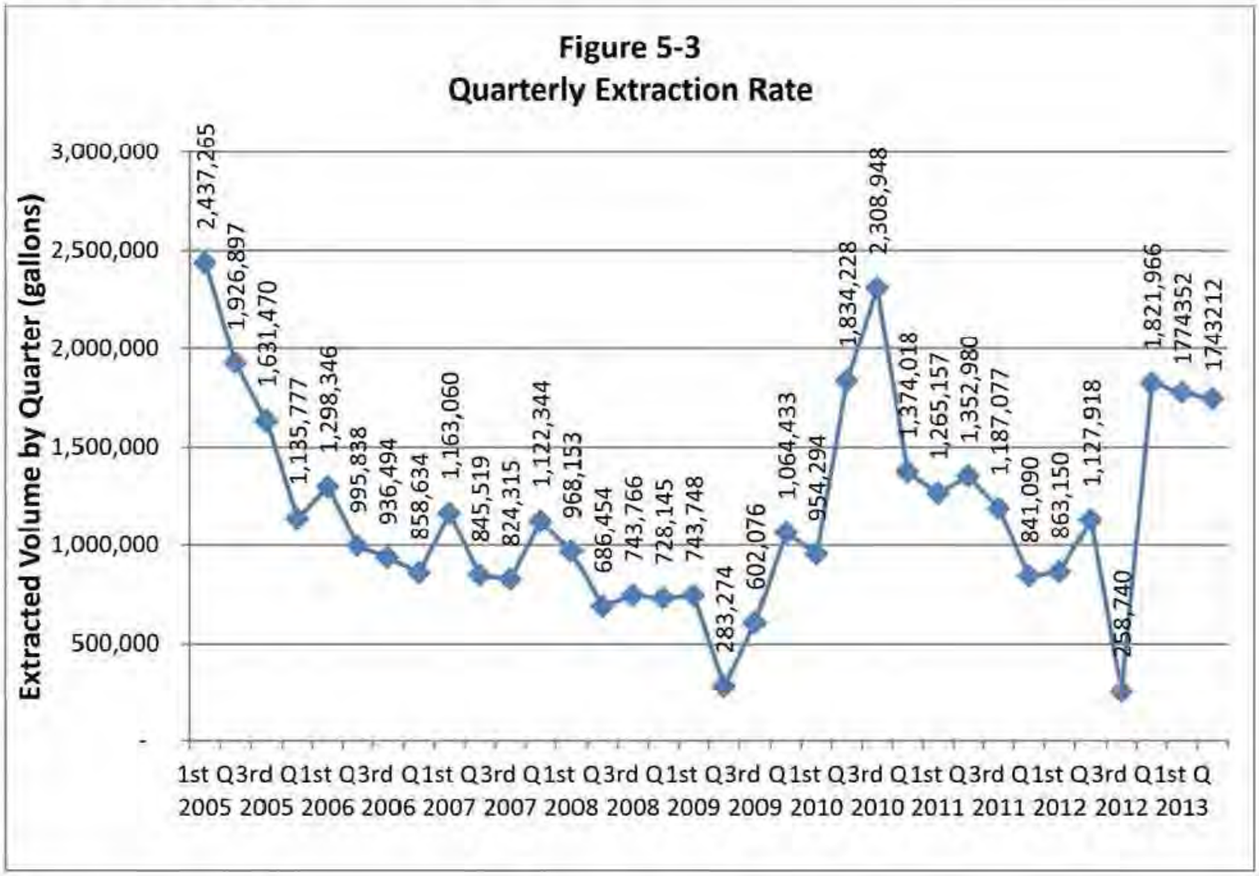
5.7.5 Groundwater Monitoring

Water levels from 65 monitoring wells and 12 piezometers are collected monthly to generate groundwater elevation maps to monitor the effectiveness of the groundwater extraction. The groundwater contours are generated using the water levels from the shallow zone and Wilcox formation wells.

The potentiometric contours in the shallow zone reflect high groundwater elevation in the central northern portion of the site with flow occurring outwardly in all directions. The highest groundwater elevation continued to occur in monitoring well 123. The potentiometric contours in the shallow saturated zone reflect influence from groundwater extraction, as depicted by steepening of the potentiometric contours upgradient of the extraction points and flattening of the potentiometric contours downgradient of the extraction points.

Although groundwater extraction continues, the groundwater high remained within the containment area (centered in the vicinity of AWD-2, AWD-3, and 123) with an outward gradient in all directions.

Several Wilcox Formation wells continued to be gauged. Generally, the Wilcox aquifer groundwater appears to have similar flow characteristics as the shallow zone with a high near the western portion of the site and radial flow to the northeast, northwest, and southwest. These flow directions appear to be influenced by site setting located between Harrison Bayou, Saunders Branch, and Caddo Lake.



5.7.6 Operations and Maintenance Conclusions

The following conclusions regarding continued O&M for this review period are:

- Significant repairs to extraction pumps, controls, and piping occurred during the review period that resulted in increase in amounts of groundwater extraction (see Figure 5-3)
- Injection to ICT6 and ICT9 was discontinued in July 2012. Re-injection might not be recommended.
- No air abatement has occurred since September 2013. Air samples are collected on a weekly basis to demonstrate compliance with TCEQ air limits. Air results continue to

demonstrate compliance with all air limits. An ESD is in progress for review/approval to operate the GWTP without an air abatement system. Army resumed operation without air abatement after receiving concurrence from EPA and TCEQ.

- Replacement or repair of major equipment such as the HCL tank, the FBR tank, meters, pumps, compressors, PLC unit, and major fittings were completed and additional optimization efforts are funded and planned to improve safety, reliability, and performance of the GWTP.
- Emergency call outs continue to occur but mainly associated with weather conditions and related to power company outages wherein or storms resulting in downed power lines or poles.
- The system is operating and efficiently removing contaminant (although due to drought conditions available groundwater to process results in the plant operating below capacity)
- During the review period it was discovered that inadequate maintenance was being completed and the Army corrected this in July of 2012. The plant is currently being maintained proactively.

5.7.7 Operations and Maintenance Costs

The approximate costs for O&M and LTM activities at LHAAP-12, LHAAP-16, and LHAAP-18/24 are not subdivided into individual site estimates, thus assessment of individual site cost performance is not possible. The original O&M total cost estimate for LHAAP-12 and LHAAP-16, and cost estimate for LHAAP-12 RAO LTM, was $75,000/year (USACE 1995a). The original O&M total cost estimate for LHAAP-18/24 was $400,000/year (USACE 1995b). The combined approximate actual O&M and LTM cost estimates for sites LHAAP-12, LHAAP-16 and LHAAP-18/24 are presented in Table 5-2.

Table 5-2: O&M and LTM Costs for LHAAP-12, LHAAP-16 and LHAAP-18/24

Calendar Year	O&M Approximate Actual Costs	LTM Approximate Actual Costs
2008	$416,328	$247,127
2009	$354,210	$112,240
2010	$354,205	$102,188
2011	$354,205	$38,628
2012	$1,118,889	$108,666

From 2007 through 2011 the annual estimates are stable or decreasing. The increased costs for 2012 are due to completion of deferred maintenance and essential upgrades to equipment and are not indicative of any effects on protectiveness and enhance effectiveness.

5.8 Progress Since the Last Five Year Review

This section provides a record of progress since the completion of the second Five-Year Report in 2008. In particular, an ESD addressing vertical extraction wells was finalized in 2010. The LHAAP-18/24 IRA system is being operated efficiently and proactively by the Army. Some deferred maintenance occurring earlier in the review period has been addressed by the Army and O&M activities are sufficiently funded throughout the next review period.

5.8.1 Previous Protectiveness Statements and Recommended Actions

The protectiveness statements from the previous Five-Year Reviews (CES 2002; Shaw 2008) are presented in Table 5-3. Recommendations/follow-up actions associated with these statements were developed in the earlier reviews. The status of those actions was evaluated as part of this review, and the results are provided in Table 5-4.

Table 5-3: Protectiveness Statements from Previous Five-Year Reviews LHAAP-018/024

First Five Year Review (CES 2002)
The Early IRA at Site 18/24 currently serves the purpose of protecting human health and the environment by controlling exposure pathways that could result in unacceptable risks. The migration of contaminants to wells screened in the intermediate and deeper groundwater zones has been stable and/or declining. The removal action and operation of the ICTs and treatment of the water at the GWTP are protective of the environment and human health by greatly reducing the chance of contaminants leaving the site. As long as the ICTs and the GWTP are in operation, this will remain true. As an early interim action this was not intended to be final solution. Risk assessments for human health and the environment are being prepared for the site in accordance with the RI/FS.
Second Five Year Review (Shaw 2008)
The IRA at LHAAP-18/24 currently protects human health and the environment because the soil remediation component removed the threats associated with source material and contaminated soil, and the groundwater extraction and treatment component ensures that there is no uncontrolled migration of the remaining contamination. The action successfully meets the RAOs identified in the IRA ROD by mitigating potential risks to human and ecological receptors posed by high concentrations of chlorinated solvents and heavy metals in the source material that was present at the site prior to the interim action and in the shallow groundwater. The excavation of source material and contaminated soil greatly reduced the mass of those contaminants that would otherwise have been available to potentially migrate off site. Comparison of contaminant data before and after implementation of the interim remedy indicates that contaminants have not spread beyond their original extent and that concentrations toward the center of the site have been reduced. Thus, operation of the groundwater extraction and treatment system protects the environment and human health by further reducing the mass of contamination within the site and by exerting local hydraulic control of the groundwater. As an IRA, the measures implemented at LHAAP-18/24 were not intended to be the final solution for LHAAP-18/24. Within the FS, the existing groundwater extraction and treatment system will be evaluated, along with other technologies, as one of the possible components of the final remedy at LHAAP-18/24.

Table 5-4: Recommendations for LHAAP-18/24 from Previous Reviews

Issue	Recommendation/Follow-up Action	Party Responsible	Oversight Agency	Milestone Date	Affects Current Protectiveness?	Affects Future Protectiveness?	Action Taken	Date of Action
Status of Recommended Actions from First Five-Year Review								
Eight Vertical Extraction Wells required by ROD not installed.	Evaluate need for wells and install or obtain release from State and USEPA	USACE	State/USEPA	11/30/02	No	Yes	.The ICTs are adequately capturing the plume. An ESD was submitted to document that ICTs satisfy IRA objectives and vertical extraction wells can be removed as possible component of the IRA.	ESD submitted August, 2010, received USEPA approval September 21, 2010
Contracting groundwater plume due to pumping may allow for reduction in number of monitoring wells sampled	Review monitoring wells sampled and change as necessary	CES / USCE	State/USEPA	11/30/02	No	No	Contractor submitted sampling modification memorandum and reduced number of wells sampled. Currently 15MWs sampled.	2006
Fencing around Site does not contain ICTs	Determine applicability for fencing around ICTs	USACE	State/USEPA	To Be Determined	No	No	Fencing configuration has proven to be adequate. New locking gate installed to prevent entry to GWTP.	~2011
Lack of restricted access signs around the Site	Place signs around site	CES / USACE	State/USEPA	5/30/02	No	Yes	Signs were installed.	~2004
Roads in Site have potholes	Fill in potholes	CES	State/USEPA	12/30/01	No	No	Not found to be an access or safety issue. No action taken.	Not Applicable
Slip flanges and bolts on pipe junctions at ICT wellheads deteriorating	Paint flanges and monitor for deterioration	CES	State/USEPA	12/30/01	No	No	Flanges were painted.	~2002
High frequency of repair of electronic equipment following lightning storms indicates need for lightning arrestors/ lightning rods to prevent damage to sensitive equipment.	Perform cost analysis for installing lightning protection	USACE	State/USEPA	12/30/01	No	No	Lightning protection system was installed.	January 2002
Metal precipitation process may not be required	Review data and monitoring information	USACE	State/USEPA	11/30/02	No	No	Open Item.	Under Revision
Control wires at Site at junction box are not protected	Protect wires at junctions	USACE	State/USEPA	5/30/02	No	No	Controls wires are now covered and enclosed in panels.	unknown
Release of approximately 50,000 gallons of untreated groundwater in January 2001	Review spill procedure and implement Freeze Protection Plan	USACE	State/USEPA	11/30/01	No	No	Freeze protection procedures were established and are implemented each winter.	~2002
Contaminants in monitor well C-6	Further investigation to determine if there is another source area.	USACE	State/USEPA	11/30/02	No	No	Shaw's review of site information indicates there is not another source area.	2007
Contamination at Northwest of burning ground outside of ICT capture zone.	Further study to determine if groundwater extraction from area is required.	USACE	State/USEPA	11/30/02	No	Yes	Open Item.	Under Revision
Monitor wells 18WW08 and 18WW17 not in perchlorate sampling of Site 18/24	CES will include these wells in Site 18/24 sampling	CES	State/USEPA	5/30/02	No	Yes	Wells were added to sampling program.	May 2000
Contaminants detected in onsite monitoring not included in investigations.	Review analysis of ICTs and monitoring wells conducted by onsite GWTP contractor . Include new contaminants in subsequent investigations as necessary.	USACE	State/USEPA	8/30/02	No	Yes	Addressed in ongoing RI/FS process for parameters identified in human health and ecological risk assessments.	Contaminants were identified in human health risk assessment (Jacobs 2002a) and ecological risk assessment (Shaw 2007a)

Issue	Recommendation/Follow-up Action	Party Responsible	Oversight Agency	Milestone Date	Affects Current Protectiveness?	Affects Future Protectiveness?	Action Taken	Date of Action
Status of Recommended Actions from Second Five-Year Review								
Perchlorate has occasional effluent results that exceed the discharge limit.	Evaluate means of reducing reporting time for perchlorate analyses for GWTP.	U.S. Army	State/USEPA	12/31/08	Yes	Yes	Based on efforts by Shaw Chemist, Shaw has found that on-site analysis is impractical. Shaw has arranged for the analytical laboratory to immediately flag any high effluent perchlorate results (results that exceed the discharge criteria) and report them to Shaw on a preliminary basis.	August 2008
Vegetation growing in fence line around the site.	Cut vegetation in fence line.	U.S. Army	State/USEPA	12/31/08	No	No	This recommendation refers to vegetation in the fence line around the GWTP. Vegetation removal activities were initiated in December 2008 utilizing Shaw's on-site personnel. Additional personnel temporarily employed to expedite removal. Removal at the GWTP was completed in April. Shaw subsequently cleared/sprayed the vegetation at the fence line at the well field itself.	April 2009
No groundwater use restrictions are in place.	Address as part of final remedy implementation of each site.	U.S. Army	State/USEPA	To be determined in site-specific RI/FS documents	No	Yes	Groundwater use restrictions will be addressed as part of the final remedy for each site. Final remedies will be determined via the CERCLA RI/FS/PP/ROD process. The draft final LHAAP-16 FS Addendum and the draft LHAAP-18/24 FS have been issued, and both documents include LUCs that restrict groundwater use.	In progress.
Metal precipitation process may not be required.	Evaluate need for process and associated sampling.	U.S. Army	State/USEPA	12/31/08	No	No	Based on review of historical data, influent metal concentrations sometimes exceed discharge criteria. Hence, the metals removal process is needed unless the discharge criteria are modified. While some of the metals criteria are more stringent than MCLs (likely because they are based on surface water quality criteria), there is currently no reason to modify those criteria. Therefore, the metals removal process should be maintained.	February 2009
Contamination northwest of burning ground.	Address as part of final remedy implementation of the site.	U.S. Army	State/USEPA	Per LHAAP-18/24 RI/FS schedule	No	Yes	Contamination northwest of the Burning Ground will be addressed in the LHAAP-18/24 FS. The draft FS has been issued and comments are being resolved.	In progress.
Eight Vertical Extraction Wells required by ROD not installed.	Evaluate need for wells and install or obtain release from State and USEPA	U.S. Army	USEPA	6/30/09	No	Yes	U.S. Army prepared an ESD. *ESD was sent to USEPA September 17, 2009 for review.	January 2010
Age and condition of piezometers	Inspect condition of piezometers during monitoring activities and, when applicable, identify for repair, replacement, or abandonment	U.S. Army	State/USEPA	12/31/08	No	No	Due to lack of information about their construction, the degree of silting at the piezometers cannot be determined. Given the concerns about their condition, the Contractor has stopped using the piezometers for potentiometric surface maps. Water levels were measured monthly through April 2009, but Contractor no longer measures water depths at the piezometers. The piezometers will be abandoned when the final remedies are implemented at LHAAP-16 and -18/24.	Deferred to final remedies.

5.8.2 Status of Ongoing Activities

The remedy evaluated in this report was established as an IRA and the final remedy is being developed through the CERCLA RI/FS process at the date of this Five-Year Review. The U.S. Army has continued to make progress at LHAAP-18/24 since completion of the previous Five-Year Reviews.

SIs have been occurring almost daily since the last Five-Year Review. Maintenance as well as periodic mowing during the growing season is routinely conducted.

Soils borings were drilled by Shaw in October of 2008 for the Draft FS study. Twelve Geoprobe - direct push technology (DPT) borings were drilled from 24-32 feet bgs (Shaw 2010a). New monitoring wells have been installed at LHAAP-18/24 as part of data collection leading to development of the Revised FS currently under development.

Groundwater sampling continues to be conducted on a semi-annual basis. Since 2007, the fifteen monitoring wells that have been routinely sampled are 18WW08, 18WW09, 18WW10, 18WW11, 18WW20, C-2, C-3, C-4, C-6, C-8, C-9, MW-16, MW-2, MW-20, and MW-8. Five of these wells (18WW08, 18WW09, 18WW10, 18WW11, and 18WW20) are located between LHAAP-18/24 and Harrison Bayou. Also included in the monitoring program is the collection of samples from Harrison Bayou at location HBW-7 which is just downstream of LHAAP-18/24. In 2012 the number of wells sampled was increased to 50 in order to re-baseline the entire data set as part of the Revised CSM for the site.

The results from the September 2012 sampling event are presented in Section 5.9. As part of the ongoing FS analyses, the monitoring well/piezometer procedures, schedules, and locations in relation to data needs are under review.

Conditions at the site have remained consistent with those mandated in the IRA ROD and there has been no change in land or groundwater use at LHAAP-18/24 since the last Five-Year Review. The intended future land use has also not changed (transfer to the USFWS for incorporation into the Caddo Lake National Wildlife Refuge), which is consistent with a non-residential level of exposure.

5.9 Five-Year Review Component

5.9.1 Administrative Review

The LHAAP Five-Year Review team was led by Dave Wacker (AECOM), who serves as AECOM Project Manager for LHAAP. The overall team was composed of the members listed in Table 5-5.

Table 5-5: Five-Year Review Team

AECOM	Project Manager: Dave Wacker Senior Engineer: Naseem Hasan, P.E. Chemist: Celia Flores Senior Review: Anne Lewis-Russ, Ph.D. Senior Risk Assessor: Rotha Randall Senior ARAR Assessor: Ruth Hammervold
LHAAP	Site Manager: Rose Zeiler
USACE	Project Engineer: Aaron Williams
USEPA	Remedial Project Manager, Rich Mayer, P.G.
TCEQ	Remedial Project Manager, April Palmie
USFWS	Paul Bruckwicki
RAB	RAB Co-Chair: Paul Fortune
RAB	RAB Co Chair: Judith Johnson RAB Member: Richard LeTourneau

The detailed Site review included the following activities:

- Review of relevant documents
- Data review
- SIs
- Local interviews
- Community involvement.

The Five-Year Review was conducted in accordance with the USEPA Comprehensive Five-Year Review Guidance (USEPA 2001). The purpose of the Five-Year Review is to determine whether the remedies selected and implemented are protective of human health and the environment. This Five-Year Review report documents any deficiencies identified during the review and recommends specific actions to ensure that a remedy is protective.

5.9.2 Community Involvement

Community notification was accomplished via interviews and publishing a notice in the local paper. The public notice was published in the Marshall News Messenger on December 14, 2012. When the Five-Year Review report is finalized, another notice will be published to indicate that the report will be available to the public at the Marshall Public Library (300 South Alamo Boulevard in Marshall, Texas 75670). The public notice is presented in Appendix B.

5.9.3 Document Review

This Five-Year Review consists of a review of relevant documents including the IRA ROD, previous Five-Year Reviews, RI, FS, risk assessments, WPs, RDs, construction and RA operation summary reports, LUC inspection logs and monitoring data. The list of documents reviewed is provided in Appendix F1.

5.9.4 Data Review

The following data review focuses on the groundwater regime, comparing monitoring well and piezometer data (analytical and physical measurements) over the previous five-year period. Also included are the recent results from SIs.

5.9.4.1 Potentiometric Surface

Groundwater elevations measured in May 2006 (before re-injection of GWTP effluent began), November 2009, and June 2012 are included in Appendix F2 (Figures F2-1, F2-2 and F2-3). The shallow zone groundwater elevation contours based on these data show that elevations were lowest in May 2006 due to drought conditions in 2005 and 2006. . The range of extremes for each is greatest for the last two events (approximately 23.5 feet, compared to the May 2006 difference of approximately 7.0 feet), reflecting an increase in gradient. Depicted in Figure F2-1 is a groundwater high near the southwest corner of the site, a fairly gradual gradient across the site, and a general flow direction to the northeast. The groundwater high is in a similar location as that presented in a USGS report that concluded there was a prominent groundwater high extending in a southwest to northeast direction in the eastern part of LHAAP 18/24. That report also noted that groundwater flowed from this high to the northwest, northeast, and southeast towards Harrison Bayou and the other small drainages near LHAAP 18/24 (Becher et al. 2012).

The depths of the groundwater zones and significant stratigraphic contacts (i.e., deep clay layer) are still under investigation in the ongoing Revised FS work. The U.S. Army updated the CSM and presented the model to the U.S. EPA and TCEQ on October 18, 2012. The updated CSM describes the presence of two units at LHAAP-18/24: a shallow unit up to a depth of approximately 50 feet bgs (shallow zone), and a deep unit below the shallow zone (Wilcox Formation). Generally, these two units are separated by a contiguous clay layer believed to be present across the entire site with the exception of the area to the west and northwest towards Harrison Bayou (i.e., within the floodplain of Harrison Bayou). As an example, it appears that the shallow zone and Wilcox Formation are well separated beyond the eastern edge of the Site (e.g., near 18WW17 and 18WW18), while there is no separation at all just beyond the western corner (i.e., in the vicinity of 18WW02 and 18WW06). In between, the clay layer beneath the shallow zone varies considerably in depth and thickness. Groundwater flow in the shallow zone occur outwardly from the Site in a radial direction. Localized influence of groundwater extraction and re-injection can be observed in the shallow aquifer (AECOM 2013).

Groundwater gauging data collected as part of the recently completed Revised FS field efforts provided an understanding of the horizontal and vertical gradients at the site. The horizontal potentiometric map remained similar to previously observed conditions with a high water level within the northwestern portion of the site and outward flow direction. Reversal of gradient was observed in the northeast area outside the containment area influenced by extraction along the northeastern boundary.

Similar observations in the southwest and northwest could not be made as directly (although an appearance of reversal of gradient might be established at certain locales such as between MW-18 and MW-8), generally due to the presence of ICT liners preventing free communication between the on-site extraction and off-site groundwater.

The data indicate the presence of an upward gradient between upper Wilcox and the shallow zone within the containment with the exception of areas of MW-5 and 18CPTMW04. The upward gradient is most likely associated with groundwater extraction.

Outside the containment area, the majority of well pairs indicated a downward vertical gradient between the shallow zone and the upper Wilcox Formation with the exception of wells pairs 18WW08/18WW09 and 18WW10/18WW11. The downward gradient reflects natural groundwater vertical gradient not influenced by groundwater extraction. The upward gradient is located in the two well pairs closest to Harrison Bayou, likely a reflection of influence of Harrison Bayou on shallow groundwater elevation

Contaminants, as defined in the 2001 BHHRA (Jacobs 2001a and b) include: bromodichloromethane, chloroform, cis-1,2-DCE, MC, TCE, antimony, barium, chromium, cobalt, manganese, nickel, silver, thallium, 4,4-Dichlorodiphenyldichloroethane, perchlorate, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), and 1,3,5-Trinitrobenzene. The selection of contaminants and the current remedial goal options (RGOs) are detailed in Section 5.10.2, below.

Based on existing data and data gap analysis presented in the PSI WP (AECOM 2013b) and subsequent in-progress Data Gap report following field work completed in April 2013, an assessment of contamination is presented below.

- The areal extent of MC decreased between 2007 and 2012. However, high concentrations of MC with some fluctuations, ranging between 327,000 µg/L and 1,170,000 µg/L continue to persist at MW-2 as indicated by 2007 through 2012 sampling results (Table 5-6). High concentrations of other COCs such as perchlorate and TCE were also observed to be present at MW-2 during this period. It should be noted that dense non-aqueous phase liquid (DNAPL) was observed in the MW-2 area in 1998/1999 that could still be present as localized source of contamination.
- High concentrations of COCs detected in MW-7, MW-8, and MW-9 [e.g., MC and TCE concentrations in MW-9 were 60,000 µg/L and 53,000 µg/L in 2009/2010 and perchlorate concentrations in MW-7 and MW-8 of 49,300 µg/L and 78,000 µg/L in March 2012] suggest that a potential source could likely exist outside the containment area or ineffective containment in the shallow zone.
- The U.S. Army is developing a Revised FS that addresses localized DNAPL contamination data gaps, and potential for vertical and lateral migration of contaminants out of the containment area.

Monitoring for the VOCs began in 1996 and for perchlorate in 2000. Contaminant concentration maps for MC, TCE, and perchlorate at LHAAP-18/24 are presented in Figures F3-1 through F3-9 (presented in Appendix F3) for monitoring in September 2007, April 2009 and March 2012 for MC, TCE and perchlorate. Plots of contaminant concentrations over time for selected monitoring wells are presented in Figures F4-1 through F4-3 (presented in Appendix F4). The plots illustrate contaminant trends in well MW-2 (near the south edge of the UEP), MW-8 (on the southwest side of LHAAP-18), and 18WW08 (northwest of LHAAP-18/24 near Harrison Bayou). Tables 5-6 through 5-8 provide groundwater MC, TCE and perchlorate concentrations for the fifteen monitoring wells sampled semi-annually.

The 2012 plume maps indicate elevated concentrations of MC and TCE within LHAAP-18, particularly around MW-2, which is just to the south of the UEP (Figures F3-7 and F3-8). The highest concentrations of MC are within the central area of the site near well MW-2. MC in the outlying wells dropped rapidly after the interim remedy began and is still low (Figure F3-7). TCE concentrations are also centered around MW-2 and the TCE plume is mainly within the area of LHAAP-18. Concentration trends at well MW-2 (Figures F3-1 through F3-9) show that MC has considerably fluctuated during the sampling period (1996 through 2012) with a significant rebound at a concentration of 1,350,000 µg/L in September 2011. TCE exhibited an initial decrease but concentrations have been somewhat variable in the last five years. These fluctuations could be attributable to the presence of finer-grained soils or period of higher than normal precipitation events or presence of unidentified source(s). Recent sampling data dated September 2012 indicate that elevated levels of MC (1,170,000 µg/L) and TCE (61,500 µg/L) persist at MW-2. The concentrations of MC (32,700-1,170,000 µg/L) and TCE (40,000-148,000 µg/L) in groundwater at MW-2 are sufficiently high to indicate the possible presence of NAPL.

Table 5-6: Methylene Chloride Concentrations (µg/L) in Monitoring Wells

Monitoring Well	Sep-2007	Mar-2008	Sep-2008	Apr-2009	Sep-2009	Mar-2010	Sep-2010	Mar-2011	Sep-2011	Mar-2012	Sep-2012
C2	2	0.25	0.25	0.25	0.25	0.25	0.25	0.407	NA	NA	NA
C3	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)
C4	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)
C6	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	11.8	ND(0.25)
C8	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)
C9	2	ND(0.2)5	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	NA	NA	NA
MW 2	1240000	974000	790000	2120000	478000	327000	533000	979000	1350000	1470000	1170000
MW 8	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	6.07	6.27	ND(0.25)	4.11	ND(0.25)	3.25	ND(0.25)
MW16	37.3	ND(0.25)	ND(0.25)	ND(0.25)	11.2	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)
MW 20	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)
18WW08	24.2	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)
18WW09	31.7	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)
18WW10	142	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)
18WW11	58.6	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	0.653	NA	NA	NA
18WW20	12.1	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)

Sources: 2001, 2006 data taken from second Five-Year Review (Shaw 2008). 2003, 2004, and 2007 data taken from FS Addendum (Shaw 2010a). All other data from AECOM project database.
Notes:
µg/L micrograms per liter
NA not available
ND not detected; values within parentheses indicate detection limits

Table 5-7: Trichloroethene Concentrations (µg/L) in Monitoring Wells

Monitoring Well	Sep-2007	Mar-2008	Sep-2008	Apr-2009	Sep-2009	Mar-2010	Sep-2010	Mar-2011	Sep-2011	Mar-2012	Sep-2012
C2	0.382	0.25	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	0.25	NA	NA	NA
C3	1.03	ND(0.25)	ND(0.25)	0.82	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	0.267
C4	0.22	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)
C6	0.22	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	1.91	ND(0.25)
C8	1.04	0.896	ND(0.25)	1.76	2.49	2.41	3.87	2.7	7.3	11.7	11.9
C9	0.302	ND(0.25)	0.338	0.25	ND(0.25)	0.25	0.25	0.25	NA	NA	NA
MW 2	98700	40000	95100	148000	54500	49400	63800	110000	57800	105000	61500
MW 8	1470	1770	1620	1790	2200	1740	1840	1140	1120	1360	959
MW16	12.1	0.467	0.316	0.419	3.49	118	24.3	34.5	8.52	59.1	38.7
MW 20	0.25	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	0.355J	ND(0.25)	
18WW08	8.79	0.405	0.83	ND(0.25)	ND(0.25)	ND(0.25)	4.09	0.858	6.12	ND(0.25)	5.09
18WW09	12.6	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)
18WW10	41.9	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)
18WW11	19.2	0.25	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	NA	NA	NA
18WW20	3.62	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)	ND(0.25)

Sources: Data from AECOM project database.
Notes:
µg/L micrograms per liter
NA not available
ND not detected; values within parentheses indicate detection limit

Table 5-8: Perchlorate Concentrations (µg/L) in Monitoring Wells

Monitoring Well	Sep-2007	Mar-2008	Sep-2008	Apr-2009	Sep-2009	Mar-2010	Sep-2010	Mar-2011	Sep-2011	Mar-2012	Sep-2012
C2	1.34 1.39 dup	0.5	0.5	1.8	ND(0.6)	ND(0.6)	ND(0.3)	ND(0.1)	NA	NA	NA
C3	997	42.7	106	1700	3.2	ND(1.2)	700	20	125	9.45	619
C4	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.11)	ND(0.6)	ND(0.3)	ND(0.3)	ND(.10)	ND(0.10)	0.483	ND(0.2)
C6	ND(0.5)	1	3.62	4.62	ND(0.6)	ND(0.5)	ND(0.6)	0.147	ND(0.10)	0.107	ND(0.2)
C8	4U	2.5	3	4	3	ND(3.0)	ND(3.0)	12.5	0.179J	ND(0.2)	ND(0.2)
C9	8	1	4.22	0.11	1.5	ND(3.0)	ND(3.0)	0.333	NA	NA	NA
MW 2	11200	9180	5660	14000	4000	3100	5700	11900	13100	8470	6940
MW 8	ND(0.5)	35200	36500	35000	38000	34000	54000	53200	64500	78000	72500
MW16	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.3)	5500	17	5.24	ND(0.10)	896	16.5
MW 20	2.67	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.3)	ND(0.45)	ND(0.3)	ND(0.10)	0.216	0.148	
18WW08	2750	610	1920	220	450	ND(1.5)	2700	22.6	2500	6.19	2080
18WW09	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.6)	ND(1.6)	ND(0.3)	ND(0.10)	ND(0.10)	0.21	ND(0.2)
18WW10	1.73	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.6)	ND(1.2)	ND(1.2)	ND(0.10)	ND(0.10)	ND(0.2)	ND(0.2)
18WW11	1	0.969 0.988 dup	ND(0.5)	ND(0.22)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.1)	NA	NA	NA
18WW20	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.11)	ND(0.3)	ND(0.3)	ND(1.3)	0.448	ND(0.2)	0.474	ND(0.2)

Sources: Data from AECOM project database.
Notes:
µg/L micrograms per liter
NA not available
ND not detected; values within parentheses indicate detection limit

Although the footprint of the perchlorate plume is mainly within LHAAP-18, some high concentrations occur to the west at MW-08 and at 18WW08 near Harrison Bayou (Figure F3-9). Groundwater perchlorate concentration increases are occurring at MW-8 (Figure F3-3) and MW-23. MW-23 is presently not included in the semi-annual monitoring wells list. Perchlorate concentrations appear to be decreasing in groundwater at well 18WW08 (Figure F3-6).

Results from the intermediate and deep groundwater zones can be examined from data currently collected from one shallow/intermediate (18WW20) and four intermediate (C-3, C-4, 18MW09, and 18MW11) monitoring wells sampled semi-annually (Tables 5-6, 5-7, and 5-8). Concentrations of contaminants, especially the VOCs, are much lower in these wells as compared to the rest of the results that are all from shallow wells.

Harrison Bayou flows within approximately 200 feet of the western corner of LHAAP-18/24 (Shaw 2010d). Currently, the monitoring program includes collection of samples from Harrison Bayou at HBW-7, just downstream of LHAAP-18/24 (Figure F3-9). Also a few of the monitoring wells in the semi-annual sampling are located between LHAAP-18/24 and Harrison Bayou (18WW11, 18WW10, C-2, MW-16, 18WW08, 18WW09, and 18WW20) (Tables 5-6, 5-7, and 5-8. Concentrations in these monitoring wells are low and many times non-detect, with the exception of the most recent perchlorate detection in 18WW08 (2,080 µg/L, September 2012).

GWTP influent and effluent sampling results over the past five years were examined. These results can be found in the GWTP Quarterly Reports that are distributed to the regulatory agencies. The effluent results were within the discharge limits except for rare perchlorate exceedances. The most recent exceedance was approximately 18 months ago (AECOM 2013a). The influent concentrations of metals have consistently been below discharge limits, with the exception of lead, which frequently exceeded the lead discharge limit in influent, but the lead effluent meets the limit prior to discharge. It is recommended that an assessment of the need to continue treatment through metal precipitation unit be made once the lead concentrations consistently meet discharge limit in influent.

Further investigation of LHAAP -18/24 was planned and approved in fall of 2012 (AECOM, 2013b) with field work completed in April, 2013. A Data Gap Report is currently under regulatory review and the Revised FS is planned for submittal in October 2013. The following is a summary of areas investigated for Data Gap evaluation:

- The role of remaining sources, including possible vadose zone contamination and localized DNAPL, in the persistence and fluctuations in contaminants concentrations is not well understood. Better delineation of contaminant distribution in the containment area, in both the vadose and saturated zones.
- The potential for both vertical and lateral migration leading to migration of contaminants out of the containment area by moving beneath the ICTs. Only one well pair suitable for assessment of vertical gradient (120 (S)/MW-14(S/I)) was historically located within the containment area. More well pairs were installed to enable a thorough evaluation of the significance of vertical gradients in contaminant migration.
- A detailed hydrostratigraphic model and tools to assess groundwater flow patterns induced by remedial measures are underway to both prevent unintended contaminant migration and to optimize mass recovery. Specific questions about whether groundwater

re-injection in ICT-6 and ICT-9 may induce flow to the south/southeast, where no containment measures exist are also being addressed.

- High concentrations of contaminants detected in MW-7, MW-8, and MW-9 [e.g., MC and TCE concentrations in MW-9 were 60,000 ug/L and 53,000 ug/L in 2009/2010 and perchlorate concentration in MW-7 and MW-8 of 49,300 ug/L and 78,000 ug/L in March 2012] could indicate either a potential source outside the containment area or ineffective containment in the shallow zone. An explanation for high contaminant concentrations in shallow groundwater will be part of the Revised FS.
- Contaminant levels immediately outside the southeast boundary of the containment area are being assessed to determine migration in that direction.
- Perchlorate and TCE have been detected between the containment area and Harrison Bayou. The downgradient extent of that impact and the potential for continued migration in that direction are part of this assessment.
- The TCE and perchlorate plumes extending to the northeast from the containment area are being fully assessed to determine the potential for continued migration in that direction.

5.9.5 Site Inspection

Representatives of the USEPA, the TCEQ, the U.S. Army, and AECOM conducted detailed SIs at LHAAP-18/24 on January 8, 2013. The purpose of the inspection was to objectively assess the operations and effectiveness of the remedy (ICT/GWTP implemented at this site. The inspection team included David Gammans, hydrogeologist, and Scott Beesinger, GWTP Operator/Manager. During the site visit, a Five-Year Review SI checklist was completed to document the status of LHAAP-18/24 (Appendix F5). Weather was clear and the temperature ranged between the low and high 50s (°F) at the time of the SI. Photographs of the site visit are presented in Appendix F6.

A summary of the SI results is as follows. The ICTs, monitoring wells and UEP appeared to be in good condition. The access road to the GWTP and also to the site is gated with a code key for entry. Piezometers and monitoring wells appeared in satisfactory condition with routine maintenance needs (painting, hinge repairs, a few missing expansion caps, minor concrete pad repairs and a missing lock). A few wet areas near the sprinkler system drainage ditches had moderate ponding.

The GWTP appeared to be well maintained and operated, and recommendations from the previous Five-Year Review had been corrected. Some of the plant equipment appeared has been recently upgraded. The plant appeared to be functioning as designed, with the exception of the Scrubber Unit out of service. The Hydrochloric Acid Tank had undergone reconditioning; however, the level probe needs an engineering review as it is no longer in use. Rust corrosion was noticed on the Activated Carbon Vessels, the_PK200B Tank, and below the PK140 Influent Holding Tank flange. Excessive growth of vegetation noted on the outside of the GWTP fence at the last Five-Year Review had been removed and the fence was clear. Maintenance records are updated daily and are reported the GWTP Quarterly Reports.

The site is enclosed by a fence posted with warning signs. Excessive growth of vegetation was noticed in some areas, mainly on southeastern portions. Several signs on the gate were illegible and need replacement, signs along the fence line were missing, and the site gate did not have a lock. A new automatic gate was installed along the road leading to the site in 2012 and the remainder of these issues have been addressed since the SI as part of regular maintenance.

5.9.6 Interview Summary

Interviews were conducted in person at the GWTP on December 20, 2012. Mr. Scott Beesinger, the O&M Site Manager/Operator, and Mr. Ray Wagner, Assistant Operator, were interviewed regarding the LHAAP-18/24 site and the GWTP. Notes from the interviews are presented in Appendix I. In summary, both interviewees stated that the GWTP is operating as designed and all indications are that the remedies are working. Most problems from the last Five-Year Review have been corrected and since AECOM has taken over the project, there has been a more focused approach with renewed project management, especially on operations and supplies. Routine maintenance has kept the project successful. It was mentioned that recent improvements in extraction well pumps (maintenance, lowering, etc.) have significantly improved extraction rates. At LHAAP-18/24, the previous use of collector trenches for injection of treated water did not seem to work. The Three Tier approach for GWTP effluent (discharge to the creek when flow allows, use of a sprinkler system, and lastly, of the lined settling pond) seems to work well. Also, in the past five years, there have been a few minor trespassing events and one act of vandalism observed in the field on the Landfill 16 Site which was addressed by installing a locking gate along Avenue P. There is a continuous presence at the site during the work week, and on the weekends the staff is on-call. Other points made were that all O&M procedures are presently under revision and optimization. Groundwater sampling locations and schedules have changed but have not significantly impacted O&M operations. The community has varying opinions about the project, with an approximately 50-50 split by those who think the level of attention and protectiveness is excellent to those who have reservations. Also, both O&M persons recommended that no extreme changes are necessary.

5.10 Technical Assessment

5.10.1 Question A: Is the remedy functioning as intended by the decision documents?

Answer: Yes

Element	Assessment
RA Performance	The final remedy has not been selected at LHAAP-18/24. The IRA ROD remedial objectives of shallow groundwater extraction and treatment using metal precipitation, air stripping, and off-gas treatment are fully underway and in the process of being optimized. Excavation and treatment of source material eliminated a large percentage of the soil contaminants. Indications are that groundwater treatment is preventing contaminants from affecting large aquifer areas and surface water. Groundwater elevation levels are monitored monthly at LHAAP-18/24 and contaminants are currently monitored semi-annually by sampling fifteen select monitoring wells. The number of monitoring wells was reduced from 47to 15 in 2007 based on evaluation of historical results and well locations. Random sampling events also occur. Semi-annual sampling is intended to continue; however, the number of sampling locations has increased along with the installation of new monitoring wells as part of the Revised FS report currently under development.
System Operations/O&M	During the review period the Army began the process of improving the level of maintenance in early 2011. The plant and extraction systems are currently being maintained proactively..
Cost of Systems Operations/O&M	The O&M cost for LHAAP-16 is combined with that of LHAAP-12 and LHAAP-18/24. Based on 2007-2011 data, the incurred costs for these three sites are stable or decreasing compared to the estimated cost with the exception of LHAAP-18/24 which requires periodic optimization or capital equipment replacement requiring additional funds.
Opportunities for Optimization	Optimization of the remedial process is ongoing. An example is the need to determine if the metals precipitation process at the GTWP should be modified or eliminated. Water levels and pump efficiency from each ICT are monitored and adjusted for maximum removal efficiency. Recent equipment upgrades have increased extraction rates. The sampling program is presently under evaluation via the Data Gap Reporting and Revised FS finalization. Elimination of re-injection needs consideration as part of final remedy selection and re-injection is no longer occurring. New monitoring wells were completed and sampled as part of the Revised FS Data Gap work. Monitoring well maintenance including repainting, relabeling, identification tags, and replacement of well head locks have been completed throughout the review period.
Early Indicator of Potential Remedy Failure	No indicators of potential remedy failure were observed during this Five-Year Review, with the exception of localized increases in perchlorate concentration in groundwater, particularly near Harrison Bayou at well MW-8.

5.10.2 Question B: Are the assumptions used at the time of remedy selection still valid?

Element	Assessment
Changes in Standards and TBC Requirements	Regulatory requirements were considered in the selection of the final remedy. The ARARs developed for the LHAAP-18/24, BG3/UEP, included in the IRA ROD (USACE 1995) and the Second Five-Year Review Report (Shaw 2008), are evaluated in Appendix C. The ROD for Site 18/24, identified specific ARARs pertaining to the site. The types of ARARs are categorized as action-specific, chemical-specific and location-specific. Descriptions of the various ARAR types are provided below: • Chemical-Specific ARARs: Chemical-specific requirements provide health- or risk-based concentration limits or discharge limitations in various environmental media for specific hazardous substances, pollutants, or contaminants. Chemical-specific ARARs are listed in Table C-1 for the LHAAP sites undergoing a Five-Year Review. • Location-Specific ARARs: Location-specific ARARs are restrictions on remedial activities solely based on the location of the remedial activity, such as certain environmentally sensitive areas. Table C-2 lists the location-specific ARARs. • Action-Specific ARARs: Action-specific ARARs are usually technology or activity-based requirements or limitations or actions taken with respect to hazardous waste sites. Action-specific ARARs are listed in Table C-3. Review of ARARSs for sites covered in this Five-Year Review did not identify any new requirements. Chemical-specific ARARs that may impact cleanup levels are discussed under "Changes in Toxicity and Other Contaminant Characteristics" below in this table.
Changes in Exposure Pathways and Land Use	LHAAP is an inactive, government-owned, formerly contractor-operated and -maintained Department of Defense facility located in central east Texas. BG3 operated from 1955 thru 1997 for the disposal of wastes associated with pyrotechnics, explosives, and propellant production. The UEP was constructed at BG3 in 1963 as a holding pond to store flammable, volatile, and pyrotechnic wastes and was closed in 1986. The IRA ROD (USACE 1995) was approved to remove and thermally treat contaminated soil and pump and treat contaminated groundwater at the on-site GWTP. The RAOs at LHAAP-18/24 were to mitigate potential risks to human and ecological receptors posed by high concentrations of chlorinated solvents and heavy metals in the shallow groundwater and source material, and to prevent contaminated groundwater from migrating to the nearby Harrison Bayou. According to the Second Five-Year Review Report (Shaw 2008), the land on which this site is located is intended for transfer to the USFWS for incorporation into the Caddo Lake National Wildlife Refuge. Future anticipated use is consistent with an industrial/recreational level of exposure. No change in land use has occurred at LHAAP-18/24 since the last Five-Year Review was prepared (Shaw 2008). No significant change in exposure pathways have occurred at the site. Both human and ecological receptor populations are also the same. The final remedies for LHAAP-18/24 will be selected as part of the in-progress FS, which will likely include an evaluation of the existing groundwater extraction and treatment system and possible LUCs. The selected remedy will be protective of human health and the environment.
Changes in Toxicity and Other Contaminant Characteristics	Without the benefit of a BHHRA, the IRA ROD (USACE 1995) established performance standards for the contaminated shallow groundwater pumped and treated at BG3. The extracted groundwater is treated to levels established in the 1995 IRA ROD. Both the First Five-Year Review Report (CES 2002) and the Second Five-Year Review Report for LHHAP-18/24 (Shaw 2008) discuss the addition of perchlorate as a contaminant for the site. The Final ROD will take into consideration the human health and ecological risk assessments for this site, data collected after 1999, and current site conditions.

Element	Assessment
Changes in Risk Assessment Methodologies	The risk assessment was not completed at the time of the IRA. The Final ROD will address risk assessment.
Toxic Remedy Byproducts	No unanticipated toxic remedy byproducts have been identified to consider in this assessment.
New Contaminants and Contaminant Sources	Potential source areas will be addressed as part of the final remedy.
Expected Progress Toward Meeting RAOs	No changes in the physical condition of LHAAP-18/24 have occurred that would affect the protectiveness of the current remedy. Sampling indicates that discharge criteria are being met.

5.10.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy

Answer: None identified, with exception of perchlorate concentrations at monitoring well MW-8, which is located near Harrison Bayou, but surface water sampling indicates no unacceptable impact.

5.11 Issues

5.11.1 Issues Identified during the Technical Assessment and Other Five-year Review Activities

Issues identified during the five-review reviews are listed below:

First Five-Year Review	• Eight Vertical Extraction Wells required by ROD not installed. • Contracting groundwater plume due to pumping may allow for reduction in number of monitoring wells sampled • Growth in fence line around the Site • Fencing around Site does not contain ICTs • Lack of restricted access signs around the Site • Roads in Site have potholes • Slip flanges and bolts on pipe junctions at ICT wellheads deteriorating • High frequency of repair of electronic equipment following lightning storms indicates need for lightning arrestors/ lightning rods to prevent damage to sensitive equipment. • Metal precipitation process may not be required • Control wires at Site at junction box are not protected • Release of approximately 50,000 gallons of untreated groundwater in January 2001 • Contaminants in monitor well C-6 • Contamination at Northwest of burning ground outside of ICT capture zone. • Monitor wells 18WW08 and 18WW17 not in perchlorate sampling of Site 18/24 • Contaminants detected in onsite monitoring not included in investigations.

Second Five-Year Review	• Perchlorate has occasional effluent results that exceed the discharge limit. • Vegetation growing in fence line around the site • No groundwater use restrictions are in place. • Metal precipitation process may not be required. • Age and condition of piezometers • Contamination at Northwest of burning ground. • Eight Vertical Extraction Wells required by ROD not installed.
Current Technical Assessment (Third Five-Year Review)	• In accord with The U.S. Army's plan to close data gaps and in response to USEPA and TCEQ responses to the Draft FS, new monitoring wells have been installed for Data Gap Closure (vertical with shallow-intermediate and deep clusters), ICT assessment, and location gaps that will be reported in the Revised FS due for submittal to regulatory agencies in October, 2013. • Some potential ICT issues with re-injection at ICT-9 could be impacting flow and needs further assessment. Some ICTs are too shallow for capture (ICT-1, -10, -12A, -13C, -13E, -13G) also 18WW17 (USGS) and need assessment. Rare perchlorate discharge from plant exceeding concentrations needs assessment. All of these items are being addressed by the Revised FS due for submittal to regulatory agencies in October, 2013. • Further optimization of system and GWTP systems including metals precipitation requirements will be evaluated as part of the Revised FS.

5.11.2 Determination of Whether Issues affect Current or Future Protectiveness

Most of the issues identified during the two previous Five-Year Reviews have been addressed. These were listed in Table 5-4.

Issues identified as part of this review are consolidated in Table 5-10.

5.11.3 Unresolved Issues

None. The two issues noted have been addressed by work completed as part of the Revised FS.

5.12 Recommendations and Follow-up Actions

Based on this Five-Year Review, the issues, recommendations, and follow actions are presented in Table 5-10.

5.13 Protectiveness Summary

The IRA at LHAAP-18/24 currently protects human health and the environment because the excavation of source material has removed the source, and the extraction and treatment of groundwater mitigates plume migration and has resulted in reductions in contaminant levels since implemented. However, in order for the remedy to be protective in the long-term, the U.S. Army has developed a draft Data Gap Report with data to be included in a Revised FS from new wells and soil and groundwater sampling completed in 2013. This document is currently under development addressing the following actions:

- Additional sampling for data gap analysis;
- Update of the CSM ;

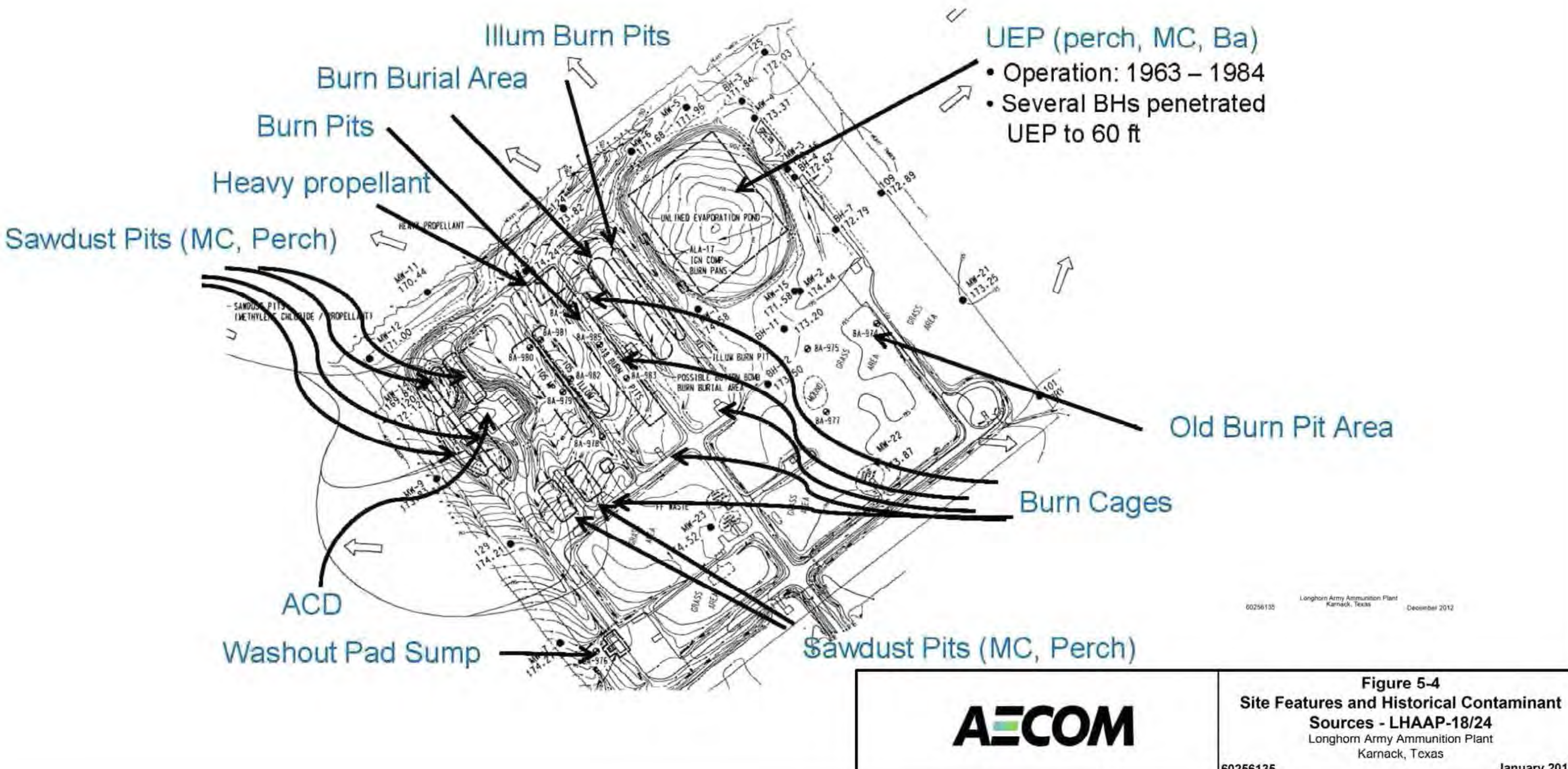
Implementation of the final remedy will also include an evaluation of the existing groundwater extraction and treatment system, possible LUCs, and MNA and will ensure protectiveness.

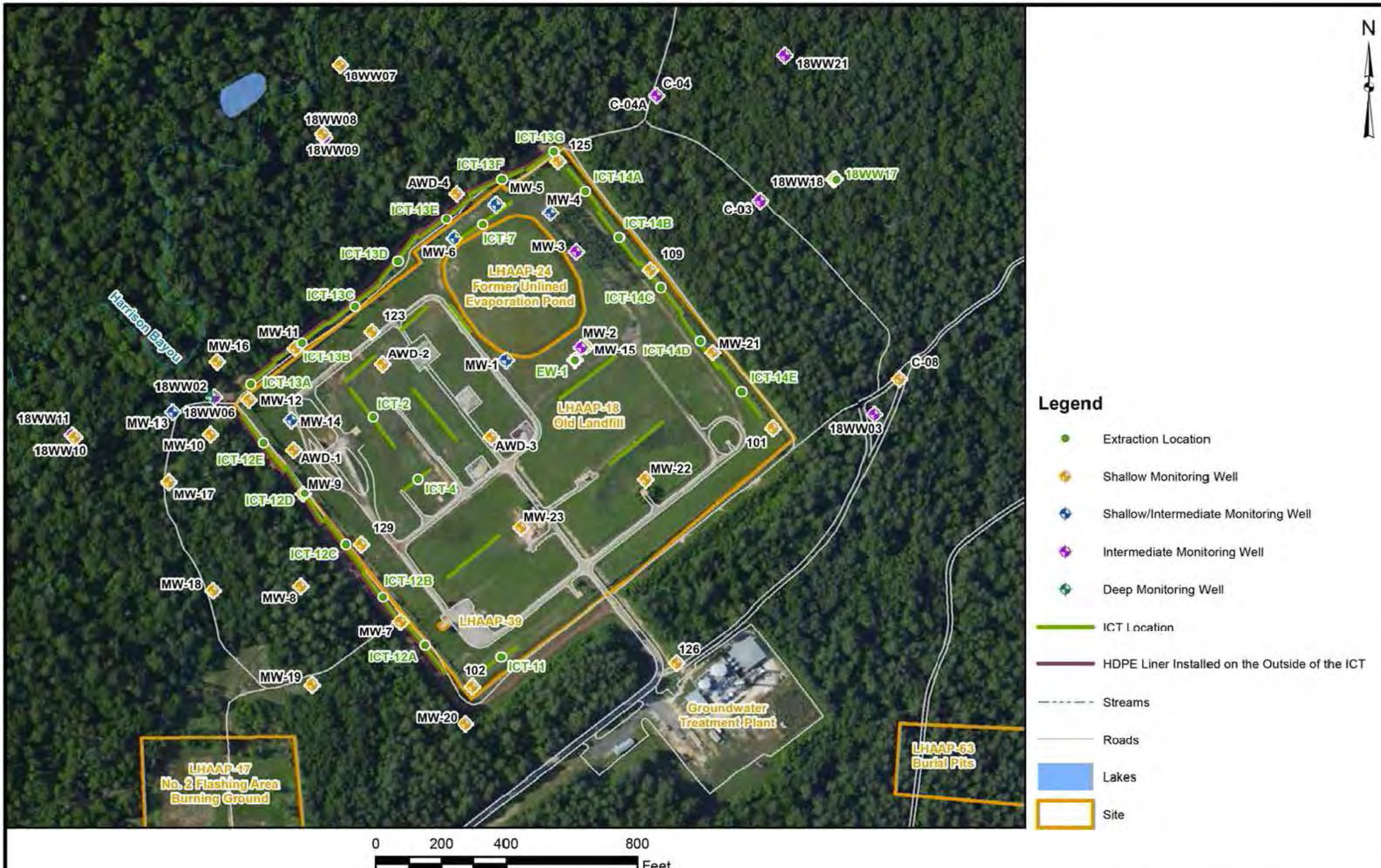
Table 5-9: Recommendations/Follow-up Actions for LHAAP-18/24

Issue	Recommendation/ Follow-up Action	Party Responsible	Oversight Agency	Milestone Date	Affects Current Protectiveness?	Affects Future Protectiveness?
Some potential ICT issues, such as re-injection at ICT-9 which could cause off-site migration, needs assessment. Some ICTs are too shallow for capture (ICT-1, -10, -12A, -13C, -13E, -13G) also 18WW17.	This work has been completed and the Data Gap Report is currently under review by the agencies. A Revised FS is also under development for submittal in October 2013	USACE	State/USEPA	October 2013	No	Yes
Rare perchlorate discharge from plant exceeding concentrations.	The Revised FS planned for submittal in October 2013 will address this issue	USACE	State/USEPA	October 2013	No	Yes

CoC Sources

- **Historical Sources**
  - **Identified in various maps based on historical site operations**





AECOM

Figure 5-5
Site Area
Layout of ICTs and GWTP Location
LHAAP-18/24
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012

6 LHAAP-49 FORMER ACID STORAGE AREA

6.1 Site Chronology

Significant events relevant to LHAAP-49 are presented in Table 6-1.

Table 6-1: Chronology of Site Events for LHAAP-49

Event	Date
Use of LHAAP-49 for formulation and storage of acids and acid mixture.	1942 to 1945
Installation RFA reviewed all sites at LHAAP and assigned numbers to identify them.	April 8, 1988
LHAAP placed on NPL.	August 29, 1990
RCRA Part B Permit signed.	February, 1992
Initial investigation including Phase III RI to identify potential site contamination at LHAAP-49.	1998-2000
Final RI Report Addendum for the Group 2 Sites RI Report, Site 49.	February 2002
Additional soil sampling focused primarily on lead and mercury contamination.	2002-2004
Additional groundwater sampling to address metals and nitrate/nitrite contamination in groundwater.	2005-2009
Final Site Evaluation Report recommending No Action Alternative for LHAAP-49.	June 2009
Final ROD for LHAAP-49.	September, 2010

6.2 History of Contamination

Figure 2-1 shows the location of LHAAP-49. This site is known as the former Acid Storage Area or the Acid Area, and is one of seven sites designated as the Group 2 sites at LHAAP. The Acid Area was used from 1942 to 1945 for formulation and storage of acids and acid mixtures in support of TNT production during World War II. Nitric acid and sulfuric acids were manufactured and handled in large quantities in this area. The site is currently wooded and grassy with the exception of two concrete buildings, numerous building foundations, and several concrete saddles and platforms previously used for the support of aboveground storage tanks. There are no known process releases that took place at LHAAP-49; however, spills could have occurred around the tanks, lines, or buildings. The original sources of contamination at LHAAP-49 probably included the buildings, piping, and tanks that were associated with on-site operations for the formulation, transfer, and storage of acids. These features may have included some components that were manufactured using lead or installed using lead-based solder. The floors of some buildings were reportedly covered with lead sheeting (Plexus Scientific Corp. [Plexus] 2005). It is also possible that some of the facilities at LHAAP-49 included instrumentation (e.g., pressure gauges, thermometers) that contained mercury that was spilled during operations or demolition. The structures, tanks, piping, and equipment at LHAAP-49 have been removed with the exception of concrete foundations/saddles and two building shells. No known contaminant sources currently remain at the site. (Shaw 2009a).

6.3 Initial Response

As part of the IRP, the U.S Army began an environmental investigation in 1976 at LHAAP followed by a record search in 1980, contamination survey in 1982, and RFI in 1988.

In addition to the installation-wide investigations, site-specific investigations were conducted in a phased approach between 1998 and 2009, to identify potential site contamination at LHAAP-49. Media investigated included soil, sediment, surface water, and groundwater. The initial investigations included a Phase III RI in 1998 and a field investigation in 2000. The results of these investigations are summarized in the Final RI Report Addendum - Group 2 Sites (Jacobs 2002c). During these 1998 and 2000 investigations, elevated levels of metals, including lead and mercury, were detected in soil. There were also scattered detections of low concentrations of pesticides, polychlorinated biphenyl, TCDDs, and one VOC (MC, a common laboratory contaminant) within the soil at LHAAP-49. In groundwater, antimony, arsenic, chromium, selenium, and nitrate/nitrite were detected above their MCLs in one or more samples. The BHHRA (Jacobs 2002a) was performed using the data presented in the Group 2 RI (Jacobs 2002c). The BHHRA identified metals as COPCs for soil and groundwater at LHAAP-49.

Further investigations were conducted after the BHHRA was completed. These investigations included sampling (2 surface soil samples) by the USFWS (USACE 2005) in 2002, sampling by the USACE (13 surface soil samples) in 2004, and sampling by Shaw (22 soils samples, 4 sediment samples, and 1 surface water sample) in 2004 (Shaw 2009a). The above soil investigations after the BHHRA focused on two metals with elevated concentrations, -lead and mercury.

Additional groundwater sampling was conducted in May 2005; October 2007; October and December 2008; and February, April, and May 2009 to address concerns about metals and nitrate/nitrite concentrations in groundwater that sometimes exceed MCLs. The sampling effort included four DPT borings, installing five monitoring wells, and collecting 14 groundwater samples. The results were presented in the Site Evaluation Report (Shaw 2009a). Evaluation of these results, together with the 1998 and 2000 groundwater results, demonstrated that the occurrences of metals and nitrate/nitrite above their MCLs were not issues that require further action at the site (Shaw 2009a).

Two soil sample locations at LHAAP-49 had mercury concentrations that were markedly higher than mercury concentrations from samples elsewhere within LHAAP-49. In 2008, a voluntary soil removal was conducted by Shaw E&I, a contractor, to address TCEQ hotspot concerns. This effort was conducted without U.S. Army input and outside the RIFS decision process. Shaw removed soil in the vicinity of these two sample locations to a depth of 1.0 feet bgs and backfilled the area with clean soil. In September 2010, EPA and USFWS collected additional soil samples at the two sample locations to confirm the absolute removal of the mercury impacted soil. The results indicated that any remaining mercury concentrations were low, at or below 27 ug/kg.

6.4 Basis for Taking Action

The No Action Alternative decision for LHAAP-49 was based on the RI (Jacobs 2002c), additional investigation data, BBHRA (Jacobs 2002b), and BERA (Shaw 2007c). The BHHRA was performed using data from the RI (Jacobs 2002c). Since that investigation, additional samples have been collected and analyzed by USFWS, USACE, and Shaw (USACE 2005; Shaw 2009a). Subsequently, a site evaluation, including an additional risk assessment, was performed to determine the impact of additional analytical results from field investigations in 2002 through 2004. It was determined that the new data do not cause the exposure concentrations to increase

(Shaw 2009a). The BHHRA results for a hypothetical future maintenance worker exposure to soil/groundwater under an industrial setting are summarized below.

Soil: The cancer risk (2.5×10^{-6}) and the non-cancer hazard (<1) are within acceptable limits established by the USEPA (1×10^{-6} to 1×10^{-4} for cancer risk and 1 for non-cancer hazard). The COPCs identified were lead, mercury, and vanadium.

Groundwater: The cancer risk (1×10^{-4}) equals the upper value of the acceptable risk range (1×10^{-6} to 1×10^{-4}). The estimated non-cancer hazard index (HI) of 2 exceeds the acceptable level (1), though no individual COPC had a HI greater than 1. TCDD exposure through the dermal pathway was responsible for elevating the cancer risk to the upper limit of the acceptable range, even though the risk is still acceptable. The contributors to the non-cancer HI of 2 for groundwater were manganese (28%), strontium (27%), nickel (22%), antimony (16%), and thallium (7%).

The groundwater results were compared to MCLs, which are specified as cleanup goals for groundwater (TCEQ 1998 and 2006), because the HI indicated the need for additional consideration of the groundwater. Several chemicals, including some that contribute to the HI, had occasional MCL exceedances. These are antimony, arsenic, chromium, nitrate/nitrite, and selenium. These COPCs were evaluated in the Site Evaluation Report (Shaw 2009a) with the following findings:

- Antimony was not detected above its MCL in recent sampling events, which used low flow sampling techniques.
- Arsenic and selenium are naturally occurring under local groundwater conditions.
- Chromium exceedances were observed in two wells. Exceedance from one well was not repeated in subsequent low flow sampling. The remaining exceedances were observed at a well with stainless steel well screen. A PVC well was installed nearby, and the chromium results were well below the MCL. This demonstrated that the elevated chromium was associated with leaching of metals from the stainless steel well screen

The potential for contamination to migrate from soil to groundwater was also evaluated (Shaw 2009a). There are no lead, mercury, or vanadium concerns in the groundwater. Vertical migration of the chemicals with the most elevated concentrations in soil (lead and mercury) was also examined using a computer model (VLEACH). The results demonstrated that these chemicals would not adversely impact groundwater.

Based on the above considerations, no COCs were identified for the groundwater at LHAAP-49.

The ecological risk for LHAAP-49 was addressed under the Industrial Sub-Area in the BERA (Shaw 2007c). The BERA concluded that no chemicals exceeded ecological thresholds of concern in the Industrial Sub Area. Therefore, no action is needed at LHAAP-49 for protection of ecological receptors.

Because hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure, a Five-Year Review is being conducted every five years to ensure protection of human health and the environment under CERCLA §121(c), U.S. Code (U.S.C.) Title 42 §9621(c).

6.5 Remedial Actions

6.5.1 Regulatory Basis for Action

The ROD (Shaw 2010b) documenting the No Action Alternative remedy for LHAAP-49 was issued by the U.S. Army, the lead agency for the installation. USEPA (Region 6) and the TCEQ are the regulatory agencies providing technical support, project review and comment, and oversight of the U.S. Army cleanup program. The risk evaluation conducted for LHAAP-49 determined that the site is suitable for nonresidential use. The USEPA and TCEQ concur with the selected No Action Alternative decision. The decision was based on the Administrative Record file for this site, including the BHHRA and RI Reports (Jacobs 2002a and c), the Final Site Evaluation Report (Shaw 2009a), the BERA report (Shaw 2007c), the Proposed Plan (U.S. Army 2010), and other related documents contained in the Administrative Record for site LHAAP-49.

The decision was chosen in accordance with CERCLA, as amended by SARA of 1986, and to the extent practicable, the NCP.

6.5.2 Remedial Action Objectives

There are no COCs identified for soil or groundwater; therefore, RAOs do not apply.

6.5.3 Remedy Description

No Action Alternative except for periodic Five-Year Reviews.

6.5.4 Remedy Implementation

A SI occurred in January 2013 to support the Five-Year Review.

6.6 Compliance Monitoring

Compliance monitoring consists of the Five-Year Review activities. Because contaminants remain at LHAAP-49 above levels that allow for unlimited use and unrestricted exposure, a Five-Year Review is conducted every five years to ensure protection of human health and the environment under CERCLA §121(c), U.S. Code (U.S.C.) Title 42 §9621(c).

6.7 Systems Operations and Maintenance

None required.

6.8 Progress Since the Last Five Year Review

This is the first Five-Year Review for LHAAP-49.

6.8.1 Previous Protectiveness Statements and Recommended Action

Not Applicable.

6.8.2 Status of Ongoing Activities

None, except Five-Year Review. The LHAAP-49 risk evaluation, which was based on the reasonably anticipated future use as a national wildlife refuge, does not address unrestricted use.

A notification was recorded in Harrison County records stating that the site is suitable for nonresidential use in accordance with TAC Title 30 §335.566.

6.9 Five-Year Review Component

6.9.1 Administrative Review

The LHAAP Five-Year Review team was led by Dave Wacker (AECOM), who serves as AECOM Project Manager for LHAAP. The overall team was composed of the members listed in Table 6-2.

Table 6-2: Five-Year Review Team

AECOM	Project Manager: Dave Wacker Senior Engineer: Naseem Hasan, P.E. Chemist: Celia Flores Senior Review: Anne Lewis-Russ, Ph.D. Senior Risk Assessor: Rotha Randall Senior ARAR Assessor: Ruth Hammervold
LHAAP	Site Manager: Rose Zeiler
USACE	Project Engineer: Aaron Williams
TCEQ	Remedial Project Manager: April Palmie
USEPA	Remedial Project Manager, Rich Mayer, P.G.
USFWS	Paul Bruckwicki
RAB	RAB Co-Chair: Paul Fortune
RAB	RAB Co Chair: Judith Johnson RAB Member: Richard LeTourneau

The review included the following activities:

- Review of relevant documents
- SIs
- Local interviews
- Community involvement.

The Five-Year Review was conducted in accordance with the USEPA Comprehensive Five-Year Review Guidance (USEPA 2001). Because contaminants remain at LHAAP-49 above levels that allow for unlimited use and unrestricted exposure, a Five-Year Review is conducted every five years to ensure protection of human health and the environment under CERCLA §121(c), U.S. Code (U.S.C.) Title 42 §9621(c). The purpose of the Five-Year Review is to determine whether the nonresidential use assumption of the no action decision remains in place. This Five-Year Review report documents any deficiencies identified and recommends specific actions to ensure that the no action decision remains protective.

6.9.2 Community Involvement

Community notification was accomplished via interviews and publishing a notice in the local paper. The public notice was published in the Marshall News Messenger on December 14, 2012.

When the Five-Year Review report is finalized, another notice will be published to indicate that the report will be available to the public at the Marshall Public Library (300 South Alamo Boulevard in Marshall, Texas 75670). The public notice is presented in Appendix B.

6.9.3 Document Review

This Five-Year Review consists of a review of relevant documents, including ROD, RI, risk assessments, and site evaluation report. The list of documents reviewed is provided in Appendix G1.

6.9.4 Site Inspection

Representatives of the USEPA, the TCEQ, the U.S. Army and AECOM carried out inspection at LHAAP-49 on January 8, 2013. The purpose of the inspection was to objectively assess the effectiveness of the nonresidential use notification at this site. During the site visit, a Five-Year Review SI checklist was completed to document the status of LHAAP-49 (Appendix G3). Weather was cloudy and the temperature ranged between low and high 50s (°F) at the time of the SI. Photographs of the site visit are presented in Appendix G4.

A summary of the SI results follows. No issues regarding land use were observed at LHAAP-49.

6.9.5 Interview Summary

Completed interview summary forms are presented in Appendix I.

6.10 Technical Assessment

This No Action Alternative site has no remedy. The five year review is implemented to confirm that the land use assumptions which formed the basis of the risk evaluation remain in place. It is recorded in the Harrison County office in accordance with 30 TAC 335.566 stating that the land is intended as a national wildlife refuge consistent with industrial or recreational activities and is suitable for non-residential use. The site is pending transfer to USFWS for incorporation into the Caddo Lake National Wildlife Refuge.

6.11 Protectiveness Summary

The No Action Alternative at LHAAP-49 is protective of human health and the environment because the risk evaluation conducted determined that the site is suitable for non-residential use and compatible with anticipated future land use as a national wildlife refuge. .

7 FORMER PISTOL RANGE (LHAAP-004-R-01)

7.1 Site Chronology

Significant events relevant to the former Pistol Range are presented in Table 7-1.

Table 7-1: Chronology of Site Events for former Pistol Range

Event	Date
Former Pistol Range established for small target practice and qualifying tests.	1950-2004
Installation RFA reviewed all Sites at LHAAP and assigned numbers currently in use to identify them.	April 8, 1988
LHAAP placed on NPL.	August 29, 1990
LHAAP, Texas Water Commission (later TNRCC and now TCEQ), and USEPA enter into a CERCLA Section 120 Agreement for remedial activities at LHAAP, referred to as the FFA.	December 30,1991
RCRA Part B Permit signed.	February, 1992
A few soil samples collected from the Former Pistol Range.	1995
Pistol Range officially closed by the U.S. Army.	2005
Comprehensive site investigation at the Former Pistol Range.	2006-2007
Non-time critical removal action at the Former Pistol Range.	2009
Final Engineering Evaluation/Cost Analysis (EE/CA) Report.	January 2010
Final Proposed Plan for the Former Pistol Range.	January 2010
Final ROD, Former Pistol Range.	August 2010

7.2 History of Contamination

Figure 2-1 shows the location of the former Pistol Range. The Pistol Range at LHAAP was established before 1954 and is known to have been used by LHAAP security personnel for small arms target practice and qualifying tests. The range was designated as an active/inactive (A/I) range during the U.S. Army range inventory process, which culminated in the LHAAP A/I Range Inventory conducted in March 2001 by the U.S. Army Materiel Command. The reason for the A/I classification was that the range was being used once a year by contract security for qualification/certification. The Pistol Range was used through 2003 and into 2004 for qualifying and recertification by security guards. The Pistol Range was officially closed by U.S. Army in 2005.

According to the Draft Historical Records Review for Other Than Operational Ranges at LHAAP, 1 June 2004, the Pistol Range was a small arms range. The *Final Environmental Site Assessment, Phase I and II Report, Production Areas, Longhorn Army Ammunition Plant* (Plexus 2005) provides a summary of historical aerial photographs and notes the Pistol Range is present in photographs from 1954 and 1955. In the 2001 inventory, the size was indicated as 0.15 acres, which is an area approximately equivalent to the northeastern portion of the range from the firing line to the target embankment. There is no visual evidence or historical record of the Pistol Range being used as anything other than a small arms firing range (Shaw 2009b).

7.3 Initial Response

The Pistol Range itself was first investigated in 1995, when a few soil samples were collected. A comprehensive investigation of the site was conducted in 2006 and 2007 (Shaw 2009b). Evaluation of the data collected in those investigations showed that lead contamination in surface and near surface soil was the only environmental concern at the site. A non-time critical removal action was implemented at the former Pistol Range in 2009 to address a potential threat to public health through exposure to high levels of lead in soil. The potential threat was eliminated through soil removal. Soil with lead concentrations exceeding 1,000 milligrams per kilograms (mg/kg) was excavated and disposed of offsite (Shaw 2009b).

7.4 Basis for Taking Action

To evaluate potential human health issues at the former Pistol Range, the soil analytical results for arsenic, copper, lead, nickel, and zinc were compared to their respective Soil/Air and Ingestion Standard for Industrial (SAI-Ind) and Groundwater Medium-Specific Concentration for Industrial Use (GW-Ind) values. For arsenic, copper, nickel, and zinc, no result exceeded the SAI-Ind. However, at three of the sampling locations at or near the target embankment at the eastern end of the former Pistol Range, soil was found to contain lead concentrations that exceeded the SAI-Ind for total lead (1,000 mg/kg). The soil containing lead at concentrations that exceeded the SAI-Ind was excavated and disposed of offsite (soil removal was verified via confirmation sampling) (Shaw 2009b).. Because some soil results in the 2006 and 2007 investigations exceeded the groundwater protection value for the industrial scenario, the potential for lead contamination to leach to groundwater was also evaluated.. The limited extent of vertical migration of lead through the soil, the lack of observed lead contamination in the groundwater, and the lack of a modeled impact to groundwater as determined by vertical transport modeling demonstrated that contamination of the groundwater was not a current or potential future problem (Shaw 2009b). The results of the 2006 and 2007 investigations also demonstrated that sediment and surface water are not impacted by the site (Shaw 2009b). In addition, the BERA did not find lead or the chemicals detected in the soil at the former Pistol range to be of ecological concern (Shaw 2007c). As a result, no RA is necessary to ensure protection of human health and the environment under the industrial land use scenario. Because hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure, a Five-Year Review is being conducted every five years to ensure protection of human health and the environment under CERCLA §121(c), 42 U.S.C. §9621(c).

7.5 Remedial Actions

7.5.1 Regulatory Basis for Action

The ROD documenting the NFA decision for the former Pistol Range was issued on August 2010. The decision was based on the Administrative Record for this site, including the Final Engineering Evaluation/Cost Analysis (EE/CA) (Shaw 2009b), Final Action Memorandum (Shaw 2009c), Final Completion Report (Shaw 2010), BERA (Shaw 2007c), and Final Proposed Plan (U.S. Army 2010).

The ROD was issued by the U.S. Army, who is the lead agency for this installation. USEPA (Region 6) and the TCEQ are the regulatory agencies providing technical support, project review and comment, and oversight of the U.S. Army cleanup program. The USEPA and TCEQ concur with the selected NFA decision.

The decision was made in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the NCP.

7.5.2 Remedial Action Objectives

This is a NFA site; RAOs do not apply.

7.5.3 Remedy Description

No Action Alternative except for periodic five year reviews.

7.5.4 Remedy Implementation

A SI occurred in January 2013 to support the Five-Year Review.

7.6 Compliance Monitoring

Because contaminants remain at former Pistol Range above levels that allow for unlimited use and unrestricted exposure, a Five-Year Review is conducted every five years to ensure protection of human health and the environment under CERCLA §121(c), U.S. Code (U.S.C.) Title 42 §9621(c).

7.7 Systems Operations and Maintenance

Not applicable.

7.8 Progress Since the Last Five Year Review

This is the first Five-Year Review for the former Pistol Range.

7.8.1 Previous Protectiveness Statements and Recommended Actions

Not applicable

7.8.2 Status of Ongoing Activities

None, except Five-Year Review. The former Pistol Range risk evaluation, which was based on the reasonably anticipated future use as a national wildlife refuge, does not address unrestricted use. A notification was recorded in Harrison County records stating that the site is suitable for nonresidential use in accordance with TAC Title 30 §335.566.

7.9 Five-Year Review Component

7.9.1 Administrative Review

The LHAAP Five-Year Review team was led by Dave Wacker (AECOM), who serves as AECOM Project Manager for LHAAP. The overall team was composed of the members listed in Table 7-2.

Table 7-2: Five-Year Review Team

AECOM	Project Manager: Dave Wacker, P.E. Senior Engineer: Naseem Hasan, P.E. Chemist: Celia Flores Senior Review: Anne Lewis-Russ, Ph.D. Senior Risk Assessor: Rotha Randall Senior ARAR Assessor: Ruth Hammervold
LHAAP	Site Manager: Rose Zeiler
TCEQ	Remedial Project Manager: April Palmie
USEPA	Remedial Project Manager, Rich Mayer, P.G.
USFWS	Paul Bruckwicki
RAB	RAB Co-Chair: Paul Fortune
RAB	RAB Co Chair: Judith Johnson RAB Member: Richard LeTourneau

The review included the following activities:

- Review of relevant documents
- SIs
- Local interviews
- Community involvement.

The Five-Year Review was conducted in accordance with the USEPA Comprehensive Five-Year Review Guidance (USEPA 2001). Because contaminants remain at LHAAP-49 above levels that allow for unlimited use and unrestricted exposure, a Five-Year Review is conducted every five years to ensure protection of human health and the environment under CERCLA §121(c), U.S. Code (U.S.C.) Title 42 §9621(c) The purpose of the Five-Year Review is to determine whether the nonresidential use assumption of the no action decision remains in-place. This Five-Year Review report documents any deficiencies identified and recommends specific actions to ensure that the no action decision remains protective.

7.9.2 Community Involvement

Community notification was accomplished via interviews and publishing a notice in the local paper. The public notice was published in the Marshall News Messenger on December 14, 2012. When the Five-Year Review report is finalized, another notice will be published to indicate that the report will be available to the public at the Marshall Public Library (300 South Alamo Boulevard in Marshall, Texas 75670). The public notice is presented in Appendix B.

7.9.3 Document Review

This Five-Year Review consists of a review of relevant documents including the ROD and EE/CA Report. The list of documents reviewed is provided in Appendix H1.

7.9.4 Site Inspection

Representatives of the USEPA, the TCEQ, U.S. Army, and AECOM carried out an inspection at the Pistol Range on January 8, 2013. The purpose of the inspection was to objectively assess whether site conditions are consistent with those mandated by the ROD. The inspection team included Dave Wacker, Gretchen McDonnell, and David Gammans. During the site visit, a Five-Year Review SI checklist was completed to document the status of Pistol Range (Appendix H2). Weather was clear and the temperature ranged between high 50s and low 60s (°F) at the time of the SI. Photographs of the site visit are presented in Appendix H3.

A summary of the SI is as follows. The site was observed to have limited access with a gated dirt road and a few signs. No significant issues were identified during the SI.

7.9.5 Interview Summary

Completed interview summary forms are presented in Appendix I.

7.10 Technical Assessment

The remedy is NFA. The only costs are the Five-Year Reviews.

7.11 Protectiveness Summary

The NFA at the former Pistol Range is protective of human health and the environment because the earlier non-time-critical removal action made the site fully compatible with the anticipated land use as a national wildlife refuge.

8 NEXT REVIEW

The next Five-Year Review for LHAAP Sites LHAAP-12, LHAAP-16, and LHAAP-18/24 is required by 2018, and will constitute the fourth Five-Year Review for these sites. The next Five-Year Review for LHAAP Sites LHAAP-49 and the Pistol Range is required by 2018, and will constitute the second Five-Year Review for these sites. The first Five-Year Review for LHAAP Sites LHAAP-37, LHAAP-46, LHAAP-50, LHAAP-58, and LHAAP-67 is required by 2018. The ROD and RAWP issuance dates for the LHAAP-37, LHAAP-46, LHAAP-50, LHAAP-58, and LHAAP-67 are listed below.

Site	ROD Issuance Date	Final RAWP Issuance Date Status
LHAAP-37	June 2010	June 2013
LHAAP-46	September 2010	March 2013
LHAAP-50	September 2010	June 2013
LHAAP-58	September 2010	August 2013
LHAAP-67	June 2010	March 2013

9 REFERENCES

AECOM Technical Services, Inc. (AECOM), 2013a. *Army Draft Quarterly Evaluation Report, 3rd Quarter (July - September) 2012, Groundwater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, TX.* January.

AECOM, 2013b. *Draft Final Post-Screening Investigation Work Plan, LHAAP-18/24, Burning Ground No. 3 and Unlined Evaporation Pond, Longhorn Army Ammunition Plant, Karnack, Texas.* February.

AECOM, 2013c. *Quarterly Evaluation Report 1st Quarter(January-March), 2012 Groundwater Treatment Plant. August.*

AECOM, 2013d. *Quarterly Evaluation Report 2nd Quarter(April-June), 2012 Groundwater Treatment Plant. September.*

Becher, Kent; Braun, Christopher; and Pearson, Daniel (Becher et al.), 2012. U.S. Department of the Interior, U.S. Geological Survey, *Evaluation of Interim Remedial Action at Longhorn Army Ammunition Plant site 18/24, Karnack, Texas*. February.

Beesinger, Scott, 2013. *Personal communication, telephone interview for details pertaining to LHAAP-18/24 and the GWTP*. January.

Complete Environmental Service, Inc., 2002. *Final Report- Five-Year Review Report- for Sites 18 & 24 (Burning Ground 3), Site 16 (Old Landfill), and Site 12 (Sanitary Landfill) at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, AR 2002 Vol 3 of 4 A, 029146-029297, 2002_1st-5yr_reviewComplEnvService.pdf. August.

Dow Environmental, Inc., 1995. *Final General Work Plan Interim Remedial Action, Burning Ground No. 3, Longhorn Army Ammunition Plant, Karnack, Texas*, Volume 1, AR 1995 Vol 11 of 10 K, 016353-016708, 1995-IRAWork Plan vol. 11 (of 10).pdf. December.

Jacobs Engineering Group, Inc. (Jacobs), 2000. *Remedial Investigation Report for Site 16 Landfill Remedial Investigation and Feasibility Study at Longhorn Army Ammunition Plant, Karnack, Texas*. October.

Jacobs, 2001a. *Final Site 16 Human Health Baseline Risk Assessment, Longhorn Army Ammunition Plant, Karnack, Texas*. June.

Jacobs, 2001b. *Draft Final Addendum to Final Site 16 Human Health Baseline Risk Assessment, Longhorn Army Ammunition Plant, Karnack, Texas*. October.

Jacobs, 2002a. *Final Report - Baseline Human Health and Screening Ecological Risk Assessment: - Volume 1: Report, for Group 2 Sites, Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake, at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, AR 2002 Vol 3 of 4 B, 029298 - 029954, 2002-vol. 03 (of 04) JacobsBaselineHlth.pdf. August.

Jacobs, 2002b. *Final Feasibility Study for Site 16, Longhorn Army Ammunition Plant, Karnack, Texas*. March.

Jacobs, 2002c. *Final Remedial Investigation Report Addendum for the Group 2 Sites Remedial Investigation Report, Site 49*, St. Louis, Missouri. February.

Plexus Scientific Corp., 2005. *Environmental Site Assessment, Phase I and II Report, Final, Production Areas, Longhorn Army Ammunition Plant, Karnack, Texas*. February.

Radian International, LLC., 1998. *Proof of Performance Test Results, Groundwater Treatment Plant, Interim Remedial Action Burning Ground No.3, Longhorn Army Ammunition Plant, Karnack, Texas*, AR 1998 Vol. 3 of 4 B, 023345-023388, 1998 Proof of Performance.pdf. June.

Shaw Environmental, Inc. (Shaw), 2004. *Screening-Level Ecological Risk Evaluation for Site 12 Soil, Longhorn Army Ammunition Plant, Karnack, Texas*. September.

Shaw, 2005a. *Final Feasibility Study, Site 12 Group 2, Longhorn Army Ammunition Plant, Karnack, Texas*, prepared for the U.S. Army Corps of Engineers, Tulsa District, January.

Shaw, 2005b. *Addendum to Final Feasibility Study, Site 12 Group 2, Longhorn Army Ammunition Plant, Karnack, Texas*, prepared for the U.S. Army Corps of Engineers, Tulsa District, March.

Shaw, 2006. *Memorandum: Sampling Modifications for LHAAP-18/24, Longhorn Army Ammunition Plant, Karnack, Texas*, Houston, Texas, October.

Shaw, 2007a. *Final Operating Properly and Successfully (OPS) Demonstration Report, Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plan, Karnack, Texas*. September.

Shaw, 2007b. *Final Remedial Design Addendum, Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plant, Karnack, Texas*. June.

Shaw, 2007c. *Final Installation-Wide Baseline Ecological Risk Assessment, Volume I*, Longhorn Army Ammunition Plant, Karnack, TX, AR 2007 Vol 10 of 25 A, 00049542 - 00050415, 2007 Final-Instln-Baseline-EcoVol10of25.pdf. November.

Shaw, 2007d. *Final Installation-Wide Baseline Ecological Risk Assessment, Volume II, Steps 4 through 8 Report and Appendices L through P, Longhorn Army Ammunition Plant, Karnack, TX*, AR 2007 Vol 21 of 25 B, 00059408 - 00060025, 2007 Final-Inst-Baseline-EcoIIVol 21 of 25.pdf. November.

Shaw, 2007e. *Sampling and Analysis Plan Groundwater Treatment Plant and Well Fields, Revision 1*, AR 2007 Vol 8 of 25 I, 00048199 - 00048283, 2007SAP-GWTP Vol 8 of 25.pdf. July.

Shaw, 2007f. *Pilot Study Implementation Plan, Groundwater Treatment Plant and Well Fields*, AR 2007 Vol 9 of 25, A, 00048895 - 00048969, 2007 Pilot study GWTP-well fields.pdf. September.

Shaw, 2008. *Final Five-Year Review, Second Five-Year Review Report for LHAAP-12, LHAAP-16 and LHAAP-18/24, Longhorn Army Ammunition Plant, Karnack, Texas*, AR 2008 Vol 9 of 9 E, 00070660 - 00070845, Sept 2008 five year review with Comnts+APPS.pdf. September.

Shaw, 2009a. *Final Site Evaluation Report, LHAAP-49, Former Acid Storage Area, Longhorn Army Ammunition Plant, Karnack, Texas*. June.

Shaw, 2009b. *Final Engineering Evaluation/Cost Analysis, Former Pistol Range, Longhorn Army Ammunition Plant, Karnack, Texas*. February.

Shaw, 2009c. *Final Action Memorandum for Former Pistol Range and LHAAP-04, Former Pilot Wastewater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, Texas.* July

Shaw, 2010a. *Final Addendum to Final Feasibility Study, LHAAP-16, Longhorn Army Ammunition Plant, Karnack, Texas*. March.

Shaw, 2010b. *Final Record of Decision, LHAAP-49, Former Acid Storage Area, Longhorn Army Ammunition Plant, Karnack, Texas.* August.

Shaw, 2010c. *Final Record of Decision, Former Pistol Range, Former Acid Storage Area, Longhorn Army Ammunition Plant, Karnack, Texas.* August.

Shaw, 2010d. *Draft Final Feasibility Study, LHAAP-18/24, Burning Ground No.3 and Unlined Evaporation Pond.* May

Shaw, 2011. *Draft Final Record of Decision, LHAAP-16, Landfill, Longhorn Army Ammunition Plant, Karnack, Texas*. Prepared for U.S. Army Corps of Engineers, Tulsa District. June.

Shaw, 2012a. *Remedial Action Operation Summary Report, Years 1 and 2 Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plan, Karnack, Texas. Rev.* July.

Shaw, 2012b. *Quarterly Evaluation Report 4TH Quarter (October-December) 2011 Groundwater Treatment Plant.* February.

Shaw, 2012c. *Quarterly Evaluation Report 2nd Quarter (April-June) 2012 Groundwater Treatment Plant. August.*

Solutions To Environmental Problems, Inc., 2005. *Final Plant-Wide Perchlorate Investigation for the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, AR 2005 Vol 3 of 5 L, 037271 -037509, 2005Perchlorate.pdf. April.

Texas Commission on Environmental Quality (TCEQ), 1998. *Interoffice Memorandum from Ronald R. Pedde to Remediation Division Staff regarding implementation of the existing risk reduction rules (a.k.a. TNRCC Consistency Memorandum)*. July.

TCEQ, 2006. *Texas Risk Reduction Rules (30TAC§335) as updated through April*. December. Access website: http://www.tceq.texas.gov/remediation/rrr.html.

TCEQ, 2008. *Email from Fay Duke to Stephen Tzhone/USEPA, Subject: LHAAP-49 Soil Removal, Austin, Texas.* September 22nd.

TCEQ, 2010. Approval Letter *Final Explanation of Significant Differences, Burning Ground 3 and Unlined Evaporation Pond (Designated as LHAAP-18/24) Interim Remedial Action Record of Decision Dated May 1995*, AR 2010 Volume 8 of 19, B, 00088920 - 00088936, LHAAP18-24ExplSigDiff2010 Vo8 of 19.pdf. February.

Thiokol Corporation, 1995. Letter from B. Singh/Thiokol to Administrative Contracting Officer, Subject: Ref. Letter dated 7 June 1995, Subject: *TNRCC Area of Concern – Lead Contamination at Pistol Firing Range*. July 20th.

U.S. Army, 1991. *Final Agreement- Federal Facility Agreement Under CERCLA Section 120, Longhorn Army Ammunition Plant, Marshall, Texas*, AR 1991 Vol 1 of D, 004332-004400, 1991Federal Facility Agreement.pdf. September.

U.S. Army, 1995. LHAAP 12 and 16 Landfills, Longhorn Army Ammunition Plant, Record of Decision, Early Interim Remedial Action. September.

U.S. Army, 2005. *Final Proposed Plan, Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plant, Karnack, Texas*. March.

U.S. Army, 2010. *Final Proposed Plan for LHAAP-16, Longhorn Army Ammunition Plant, Karnack, TX.* September.

U.S. Army Corps of Engineers (USACE), 1989. *Final Report - Phase I RCRA Facility Investigation (RFI) Active Burning Ground and Unlined Evaporation Pond Volume 1 -* Text, AR 1989 Vol 1 of 5 A, 001910-002056, 1989RCRA Inv Logs2060-2063to2074-2079.pdf. July.

USACE, 1995a. *Record of Decision For Early Interim Remedial Action At The LHAAP 12 and 16 Landfills, Longhorn Army Ammunition Plant, Karnack, TX,* September.

USACE, 1995b. *Record of Decision For Early Interim Remedial Action At Burning Ground No.3, Longhorn Army Ammunition Plant, Karnack, Texas*, AR 1995 Volume 2 of 11,N, 012681 - 012751, LHAAP18+24ROD1995.pdf. May.

USACE, 2006. *Final Record of Decision, Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plan, Karnack, Texas, Revision 2*. April.

USACE, 2007. *Final Groundwater Monitoring Report Sites 12 and 16, Spring 2003, Spring 2004, and Winter 2004, Longhorn Army Ammunition Plant*. January.

USACE, 2010a. *Final Record of Decision, LHAAP-35B(37), Chemical Laboratory and LHAAP-67, Aboveground Storage Tank Farm, Longhorn Army Ammunition Plant*, June.

USACE, 2010b. *Final Explanation of Significant Differences, Burning Ground 3 and Unlined Evaporation Pond (Designated as LHAAP-18/24) Interim Remedial Action Record of Decision Dated May 1995, Longhorn Army Ammunition Plant, Karnack, Texas*, AR 2010 Volume 8 of 19, B, 00088920 - 00088936, LHAAP18-24ExplSigDiff2010 Vo8 of 19.pdf. August.

USACE and ALL Consulting, 2006. *Final Groundwater Monitoring Report, Sites 12 and 16, Spring 2003, Spring 2004, and Winter 2004, Longhorn Army Ammunition Plant, Texas*. January.

U.S. Army Environmental Hygiene Agency, 1980. *Final Report - AEHA Land Disposal Study No. 38-26-0104-81-82, AEHA Aberdeen Proving Ground*, AR 1980 Vol 1 of 1, 000078 - 000196, 1980LandDispStdy-vol. 01.pdf. February.

USEPA, 2001. Office of Emergency and Remedial Response (5204G), *Comprehensive Five-Year Review Guidance*, EPA 540-R-01-007, OSWER No. 9355.7-03B-P. June.

USEPA, 2009. Revised Assessment Guidance for Perchlorate.
Access website: www.epa.gov/fedfac/documents/perchlorate_memo_01-08-09.pdf

USEPA, 2012. *Regional Screening Levels for Chemical Contaminants at Superfund Sites*. EPA Office of Superfund. November.
Access website: http://www.epa.gov/region9/superfund//.

APPENDIX A: Not Used

APPENDIX B: Public Notice

PUBLIC NOTICE

THE UNITED STATES ARMY IS BEGINNING A COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT FIVE YEAR REVIEW FOR SIX SITES AT THE FORMER LONGHORN ARMY AMMUNITION PLANT IN KARNACK, TEXAS

The U. S. Army is the lead agency for environmental response actions at the former Longhorn Army Ammunition Plant (LHAAP) located in Karnack, TX. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires the lead agency to review the status of sites closed to industrial standards or where interim remedies are in place to ensure the clean-up is still protective of human health and the environment. In partnership with Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency Region 6, the U.S. Army is beginning a Five Year Review for six LHAAP sites: LHAAP-12, LHAAP-16, LHAAP-18, LHAAP-24, LHAAP-49 and a former Pistol Range (LHAAP-004-R-01). A brief description of each site is below.

LHAAP-12 is a 7 acre inactive landfill that was used for disposal of non-hazardous industrial wastes. The landfill was closed in 1994 and a cap was constructed over the landfill as part of Interim Remedial Action (IRA) in 1998. The landfill cap is the final action planned for soil at LHAAP-12. Groundwater contamination is also present at LHAAP-12. Trichloroethene (TCE, an industrial solvent) is the primary contaminant. The final remedy consisting of land use controls (LUCs) and monitored natural attenuation (MNA) is in place to address groundwater contamination.

LHAAP-16 is a 20 acre inactive landfill originally established in the 1940s and used for the disposal of solid and industrial wastes until the 1980s when disposal activities were terminated. A landfill cap was constructed over the landfill contents in 1998 and LUCs are currently in place. A groundwater extraction system was voluntarily installed by the U.S. Army in 1996 and 1997 to prevent the groundwater plume from migrating to near-by Harrison Bayou. The extraction system has now been operating for over 15 years. The landfill cap is the final action planned for soil at LHAAP-16. Groundwater contaminants include TCE, other volatile organic compounds and perchlorate. The final remedy for LHAAP-16 was established in the Record of Decision (ROD) issued in September 2011. The final selected remedy includes maintenance of the existing cap, enhanced LUCs, enhanced in-situ bioremediation in a target area, biobarriers, and MNA. This work is planned for completion in 2013.

LHAAP-49 is known as the former Acid Storage Area. Nitric acid and sulfuric acid were manufactured and handled in large quantities in this area. There are no known process releases that took place at LHAAP-49. The risk evaluation conducted for LHAAP-49 determined that the site is suitable for nonresidential use with Five Year Reviews required. Based on the ROD issued on August 2010, no other action is necessary at LHAAP-49 to protect public health or the environment.

LHAAP-18 and **LHAAP-24** are the former Burning Ground (No.3) and an Unlined Evaporation Pond. The three-acre Unlined Evaporation Pond was constructed in 1963 within Burning Ground No. 3 (total of 34.5 acres), and was closed in 1985 by removing waste and capping. In May 1995 an Interim Remedial Action - Record of Decision was signed requiring Soil Remediation and Groundwater Extraction and Treatment. In 1997, a soil removal action was completed and a Groundwater Treatment Plant (GWTP), with approximately 5,000 feet of groundwater interception and collection trenches, was installed and began operation. COCs include metals, VOCs and perchlorate. Fluidized Bed Reactor Treatment for perchlorate began at the GWTP in 2001. Final remedies for Sites LHAAP-18 and LHAAP-24 are currently under development as part of a Feasibility Study leading to a final clean-up remedy planned for 2013.

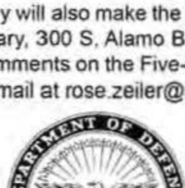
LHAAP-004-R-01, a former pistol range is located in the southeastern portion of LHAAP and covers an area of approximately 0.4 acres. The area was used by base security personnel as early as the 1950s and intermittently through 2004 as a small arms firing range. The target area was a natural, wooded slope at the eastern side of the site. Soil with contamination above industrial cleanup levels was excavated and disposed off site during a 2009 removal action. No further action is planned for the site.

The Five Year Review of these sites will be conducted to ensure that response actions and final recommendations remain protective of human health and the environment. The U.S. Army will also conduct community involvement activities, including this notice, as well as a follow-on notice when the Five Year Review report is available for review by the public, and updates provided at quarterly Restoration Advisory Board meetings planned for January, April and July, 2013.

To facilitate public participation, the U.S. Army will also make the Draft Five-Year Review Report available for public review at the Marshall Public Library, 300 S. Alamo Blvd, Marshall, TX, 75670. To request an email copy of the document or to provide comments on the Five-Year Review report, please contact: Ms. Rose Zeiler, Ph.D., at 479-635-0110 or by email at rose.zeiler@us.army.mil.

For further information call or email:

Rose Zeiler, Ph.D.
479-635-0110
rose.zeiler@us.army.mil



US Army Corps of Engineers ®
Tulsa District

APPENDIX C: Applicable or Relevant and Appropriate Requirements

Appendix C – Applicable or Relevant Appropriate Requirements

Section 121(d)(1) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 specifies that remedial actions for cleanup of hazardous substances must comply with requirements or standards under federal or more stringent state environmental laws and regulations that are applicable or relevant and appropriate to the hazardous substances or particular circumstances at a site or obtain a waiver. Inherent in the interpretation of applicable or relevant and appropriate requirements (ARARs) is the assumption that protection of human health and the environment is ensured. Under CERCLA Section 121(e), on-site remedial response actions need only comply with the substantive requirements of a regulation and not the administrative requirements.

If the selected remedial action results in the hazardous substance pollutant or contaminant remaining above levels for unlimited use, a review is required every five years (40 CFR Part 300.430(f)(4)9ii). The Longhorn Army Ammunition Plant (LHAAP) consists of the following sites subject to this Five-Year Review:

- Site 12 Landfill
- Site 16 Landfill
- Site 18/24 Unlined Evaporation Pond

The National Contingency Plan requires that the requirements applicable to a release or remedial action that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance be identified (40 CFR Part 300.400(g)(1). ARARs include only federal and state environmental laws/regulations and do not include occupational safety regulations. Applicable requirements are the environmental requirements that specifically address the circumstance at a CERCLA site (40 CFR 300.5); that is, if they directly and fully address the situation at the site. Relevant and appropriate requirements are the environmental requirements that address the circumstance sufficiently similar to those at the site. A relevant and appropriate requirement must be complied with to the same extent as the applicable requirement. Non-promulgated federal or state advisories or guidance may be identified as to-be-considered (TBC) guidance. TBCs may be considered and used where necessary to ensure protectiveness.

This appendix documents the federal and state chemical-, location-, and action-specific ARARs, as well as TBC guidance for the remediation of the above sites as specified in the applicable decision document for sites LHAAP-12, LHAAP-16, and LHAAP-18/24.

Table C-1: Chemical-Specific ARARs
Sites 12 and 18/24

Source	Standard, Requirement, Criteria or Limitation	Scope	ARAR/TBC Status	Requirement/Action
Texas MSCs for nonresidential exposure	30 TAC 335.559(d)(2)	Site 12	Relevant and appropriate for industrial worker exposure to groundwater.	Establishes groundwater MSCs (GW-Ind) if a federal MCL has not been promulgated.
RCRA hazardous waste	40 CFR 261	Site 18/24	Relevant and appropriate	Metals and other treamtent mateirals that are hazardous wastes will be managed in accordnace with rCRA
Early IRA ROD Discharge Criteria	See Table 2 of IRA ROD, Early Interim Action at Burning Grounds 3, Army, May 1995	Site 18/24	Relevant and apporpriate for water discharged from the plant to Harrison Bayou following treatment.	Comparison table for analytical data to enable monitoring of quality of water returned to Harrison Bayou.

CFR - Code of Federal Regulations
MCL - Maximum Contaminant Level
MSC - Medium-specific concentrations
TAC - Texas Administrative Code
USC - United States Code

Table C-2: Location-Specific ARARs
Sites 12, 16, and 18/24

Source	Standard, Requirement, Criteria or Limitation	Scope	ARAR/TBC Status	Requirement/Action
National Historic Preservation Act of 1966 and Texas Preservation Trust Fund	36 CFR 60, 36 CFR 65 and 36 CFR 800 13 TAC 16, 17 and 25	No known historic locations are present at any of the subject sites (Sites 12, 16, and 18/24)	Applicable if remediation activities are located near historic locations.	Current activities are not expected to disturb any additional land although Site 18/24 may have future remedy activities that could be impacted. Any historic resource must be identified , designated and protected.
Restoration of groundwater	CFR 300.430(a)(1)(iii)(f); Texas Water Code 26.401	Site 18/24	Applicable	Texas groundwater rules require restoration of contaminated groundwater if feasible
Floodplain Management and Protection	40 CFR 264.18	Site 16, 18/24	Applicable for activities located near the 100-year flood plain or designated wetlands.	Part of the brunding groudnw and LHAAP16 are within the 100 year floodplain

CFR - Code of Federal Regulations
TAC - Texas Administrative Code

Table C-3: Action-Specific ARARs
Sites 12, 16, and 18/24

Source	Standard, Requirement, Criteria or Limitation	Scope	ARAR/TBC Status	Requirement/Action
National Pollution Discharge Elimination System	40 CFR Part 125 and 30 TAC	Sites 12, 16, 18/24	Applicable if water is discharged to a surface water body or wetland.	Discharges to waters of the State must meet the NPDES requirements.
Post Closure Care Requirements for Hazardous Waste Landfills	40 CFR 264.310(b) and 30 TAC 335.174(b)	Sites 12 and 16	Relevant and appropriate to post closure under CERCLA of landfills containing RCRA hazardous waste. Currently Sites 12 and 16.	Owner or operator must: • maintain the effectiveness and integrity of the final cover including making repairs to the cap as necessary; • prevent run-on and run-off from eroding or otherwise damaging the final cover; and • maintain and monitor a groundwater monitoring system.
Air Emissions (Permit by Rule)	30 TAC 116 (30 TAC 335.565 and 335.566)	Site 18/24	Relevant and appropriate	Air emissions from groundwaer treatment process will be in accordance witrh 30 TAC 116 (now Permit by Rule).
CWA	40 CFR Parts 133 and 230 and 33 CFR Parts 320-330	Sites 12 and 16	Relevant and appropriate	Applies to construction of a fill in a wetlands area.

Notes:
ARAR - Applicable or Relevant and Appropriate Requirements
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
CFR - Code of Federal Regulations
CWA - Clean Water Act
GWTP - groundwater treatment plant
NPDES - National Pollutant Discharge Elimination System
RCRA - Resource Conservation and Recovery Act
ROD - Record of Decision
TAC - Texas Administrative Code
TBC - to be considered

APPENDIX D: LHAAP-12 Supporting Documents

APPENDIX D1: Documents Reviewed

Documents Reviewed for LHAAP-12

Complete Environmental Service, Inc., 2002. *Final Report- Five-Year Review Report- for Sites 18 & 24 (Burning Ground 3), Site 16 (Old Landfill), and Site 12 (Sanitary Landfill) at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, AR 2002 Vol 3 of 4 A, 029146-029297, 2002_1st-5yr_reviewComplEnvService.pdf. August

Jacobs, 2001. *Final Remedial Investigation Report, Group 2 Sites, Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, April.

Jacobs, 2002. *Draft Final Feasibility Study for the Group 2 Sites (Sites 12, 17, 18/24, 29, 32,and 49), Longhorn Army Ammunition Plant, Karnack, Texas, Prepared for the U.S. Army Corps of Engineer.* May.

Jacobs, 2002. *Final Report - Baseline Human Health and Screening Ecological Risk Assessment: - Volume 1: Report, for Group 2 Sites, Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake, at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas,* AR 2002 Vol 3 of 4 B, 029298 - 029954, 2002-vol. 03 (of 04) JacobsBaselineHlth.pdf. August.

Plexus Scientific Corp., 2005. *Environmental Site Assessment, Phase I and II Report, Final, Production Areas, Longhorn Army Ammunition Plant, Karnack, Texas*. February.

Shaw, 2004. *Final Work Plan, Groundwater Data Gaps Investigation, Groups 2 and 4, Longhorn Army Ammunition Plant, Karnack, Texas*. February.

Shaw, 2004. *Screening-Level Ecological Risk Evaluation for Site 12 Soil, Longhorn Army Ammunition Plant, Karnack, Texas.* September.

Shaw, 2005. *Final Feasibility Study, Site 12 Group 2, Longhorn Army Ammunition Plant, Karnack, Texas,* prepared for the U.S. Army Corps of Engineers, Tulsa District. January.

Shaw, 2005. *Addendum to Final Feasibility Study, Site 12 Group 2, Longhorn Army Ammunition Plant, Karnack, Texas,* prepared for the U.S. Army Corps of Engineers, Tulsa District. March.

Shaw, 2005. *Project Management Plan for Site Closure of Multiple Sites, Longhorn Army Ammunition Plant, Karnack, Texas*, November.

Shaw, 2007. *Final Remedial Design Addendum, Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plant, Karnack, Texas*. June.

Shaw, 2007. *Final Operating Properly and Successfully (OPS) Demonstration Report, Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plan, Karnack, Texas*. September.

Shaw, 2007. *Final Installation-Wide Baseline Ecological Risk Assessment, Volume I,* Longhorn Army Ammunition Plant, Karnack, TX, AR 2007 Vol 10 of 25 A, 00049542 - 00050415, 2007 Final-Instln-Baseline-EcoVol10of25.pdf. November.

Shaw, 2008. *Final Five-Year Review, Second Five-Year Review Report for LHAAP-12, LHAAP-16 and LHAAP-18/24, Longhorn Army Ammunition Plant, Karnack, Texas*, AR 2008 Vol 9 of 9 E, 00070660 - 00070845, Sept 2008 five year review with Comnts+APPS.pdf. September.

Shaw, 2012. *Remedial Action Operation Summary Report, Years 1 and 2 Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plan, Karnack, Texas. Rev.* July.

Shaw, 2012. *Remedial Action Operation Summary Report, Years 3 and 4 Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plan, Karnack, Texas. Rev 0.* July.

Solutions To Environmental Problems, Inc., 2005. *Final Plant-Wide Perchlorate Investigation for the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, AR 2005 Vol 3 of 5 L, 037271 -037509, 2005Perchlorate.pdf. April.

U.S. Army Corps of Engineers (USACE), 2006. *Final Record of Decision, Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plan, Karnack, Texas, Revision 2.* April.

USACE and ALL Consulting, 2006. *Final Groundwater Monitoring Report, Sites 12 and 16, Spring 2003, Spring 2004, and Winter 2004, Longhorn Army Ammunition Plant, Texas.* January.

U.S. Army, 1991. *Final Agreement- Federal Facility Agreement Under CERCLA Section 120, Longhorn Army Ammunition Plant, Marshall, Texas*, AR 1991 Vol 1 of D, 004332-004400, 1991Federal Facility Agreement.pdf. September.

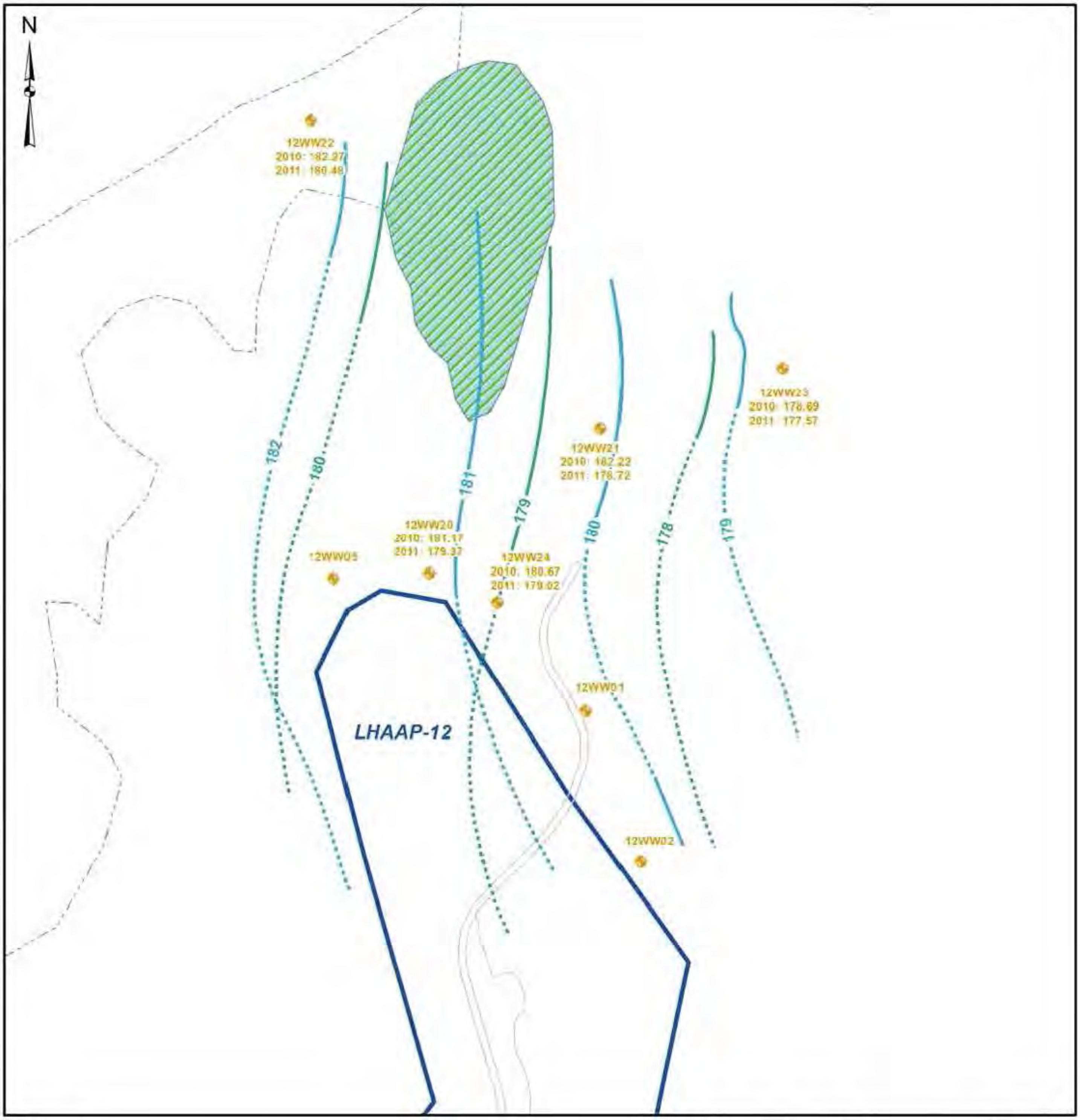
U.S. Army, 1995. LHAAP 12 and 16 Landfills, Longhorn Army Ammunition Plant, Record of Decision, Early Interim Remedial Action. September.

U.S. Army, 2005. *Final Proposed Plan, Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plant, Karnack, Texas*. March.

USEPA, 2001. Office of Emergency and Remedial Response (5204G), *Comprehensive Five-Year Review Guidance*, EPA 540-R-01-007, OSWER No. 9355.7-03B-P. June.

USEPA, 2009. Revised Assessment Guidance for Perchlorate.
Access website: www.epa.gov/fedfac/documents/perchlorate_memo_01-08-09.pdf

APPENDIX D2: Groundwater Elevation Maps



Legend

0 100 200 400 Feet

- Shallow Monitoring Well
- 2010 Groundwater Gradient Contour (Dashed Where Inferred)
- 2011 Groundwater Gradient Contour (Dashed Where Inferred)
- Streams
- Roads
- Drainage Feature
- Site (Boundary of Landfill Cap)

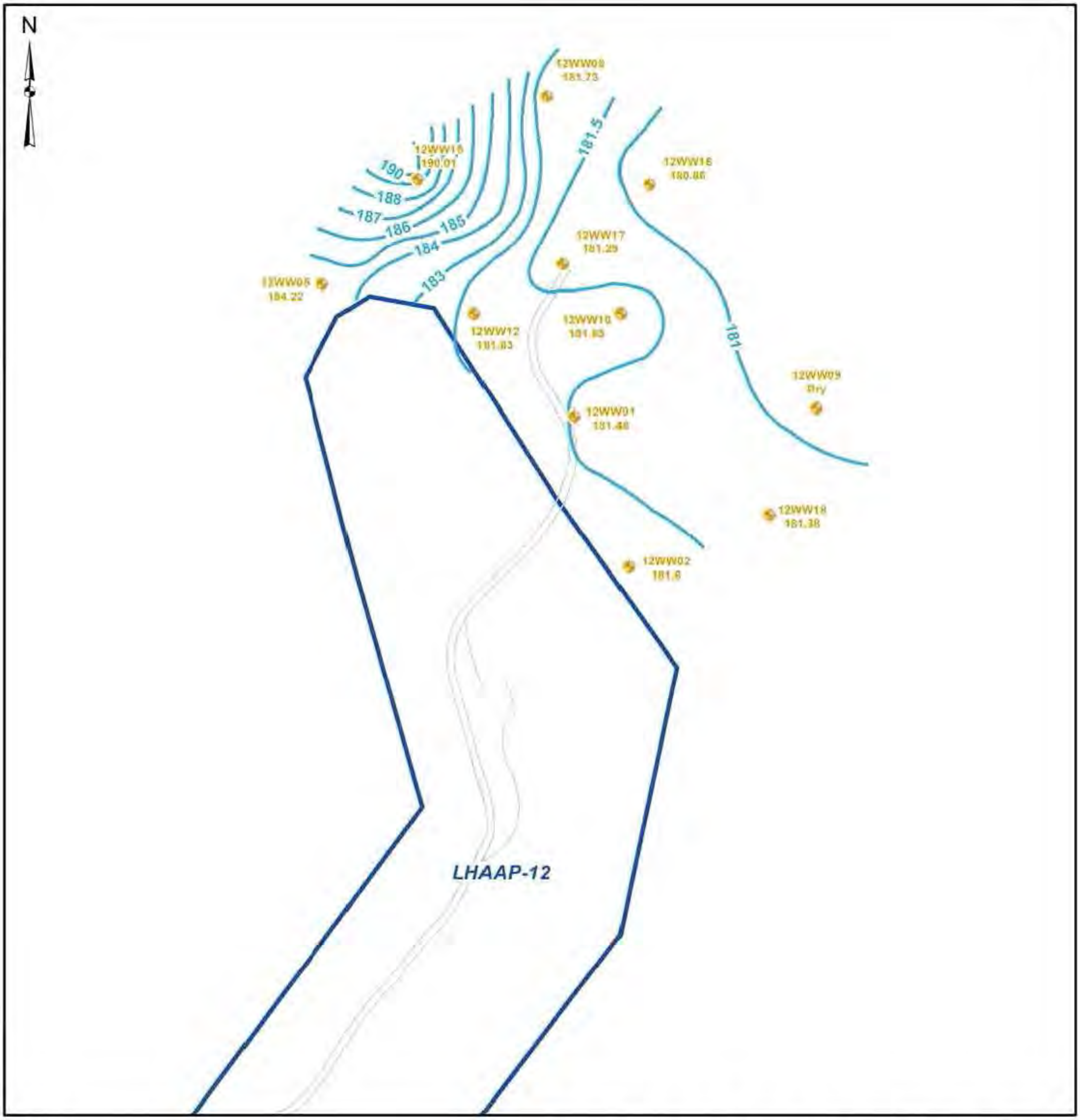
Source: Shaw 2012, Final Remedial Action Operation Summary Report, Tiers 3 and 4, LHAAP-12.

AECOM

D2-1
Groundwater Gradient Map
December 2010 and 2011
LHAAP-12
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012



Legend

- Shallow Monitoring Well
- Shallow Groundwater Elevation - February 2003
- Roads
- LHAAP-12 Landfill Fence

Source: Figure from the "Final Groundwater Monitoring Report Sites 12 and 16, Spring 2003, Spring 2004, and WInter 2004, Longhorn Army Ammunition Plant, Karnack, Texas. ALL Consulting, January 2006.

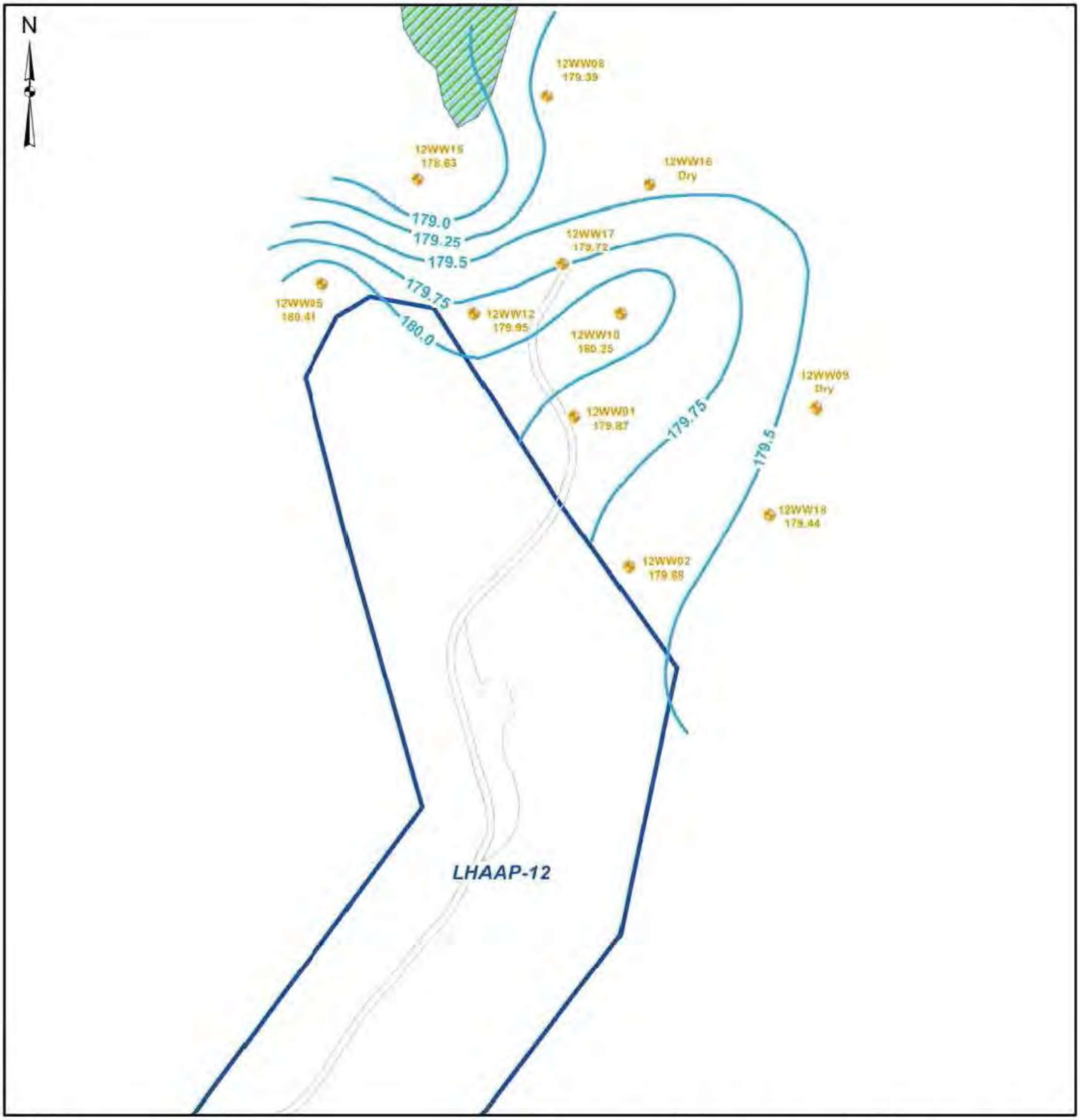
0 100 200 400
Feet

AECOM

Figure D2-2
Groundwater Gradient Map
February 2003
LHAAP-12
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012



Legend

- Shallow Monitoring Well
- Shallow Groundwater Elevation - February 2004
- Roads
- LHAAP-12 Landfill Fence

Source: Figure from the "Final Groundwater Monitoring Report Sites 12 and 16, Spring 2003, Spring 2004, and WInter 2004, Longhorn Army Ammunition Plant, Karnack, Texas. ALL Consulting, January 2006.

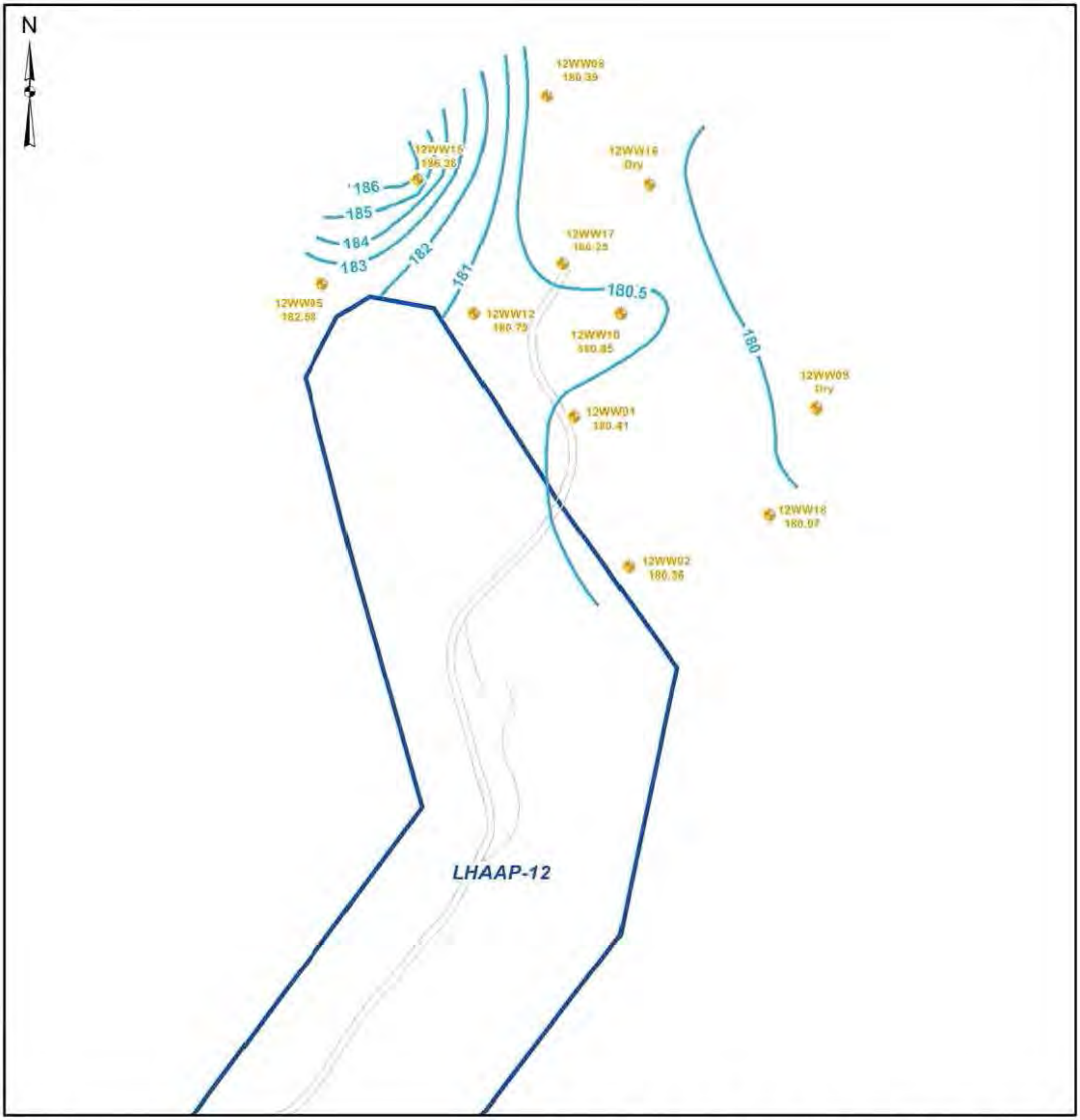
0 100 200 400
Feet

AECOM

Figure D2-3
Groundwater Gradient Map
February 2004
LHAAP-12
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012



Legend

- Shallow Monitoring Well
- Shallow Groundwater Elevation - December 2004
- Roads
- LHAAP-12 Landfill Fence

Source: Figure from the "Final Groundwater Monitoring Report Sites 12 and 16, Spring 2003, Spring 2004, and Winter 2004, Longhorn Army Ammunition Plant, Karnack, Texas. ALL Consulting, January 2006.

0 100 200 400 Feet

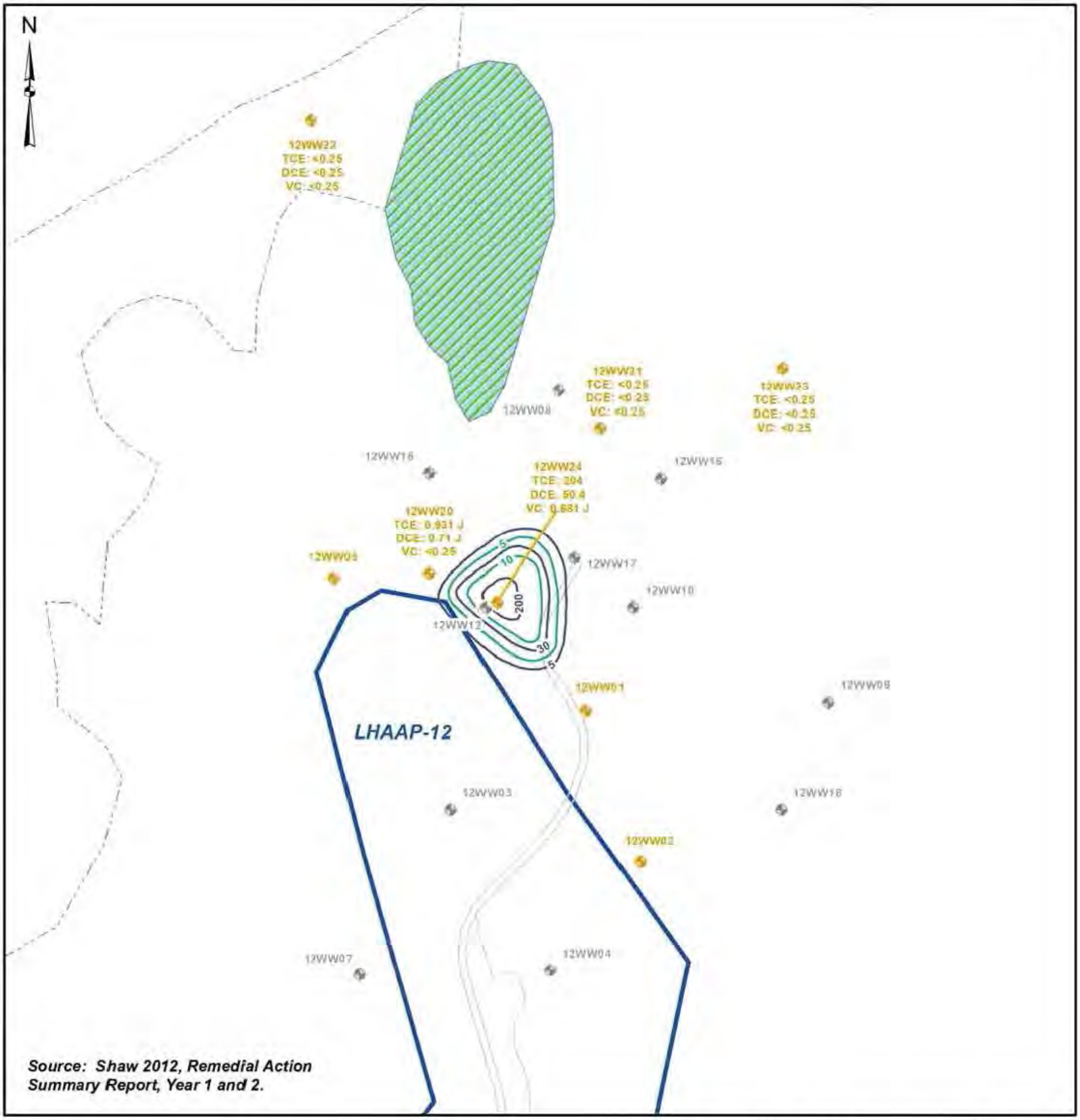
AECOM

Figure D2-4
Groundwater Gradient Map
December 2004
LHAAP-12
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012

APPENDIX D3: Groundwater/Soil Concentration Maps



Source: Shaw 2012, Remedial Action Summary Report, Year 1 and 2.

Legend

	Existing Shallow Monitoring Well		Streams
	Abandoned Shallow Monitoring Well		Roads
	TCE (Trichloroethene) Concentration Isopleth		Drainage Feature
	cis-1,2-DCE (Dichloroethene) Concentration Isopleth		Site (Boundary of Landfill Cap)

0 100 200 400 Feet

Notes:
1. Concentrations reported in µg/L.
2. Concentrations shown ar 12WW20, 12WW21, 12WW22, 12WW23, and 12WW24 are from July 2009 sampling event.
3. MCL (Maximum Contaminant Level) for TCE if 5 µg/L, for DCE is 70 µg/L, and for VC is 2 µg/L.
4. "DCE" Concentrations indicated are cis-a,2-DCE.

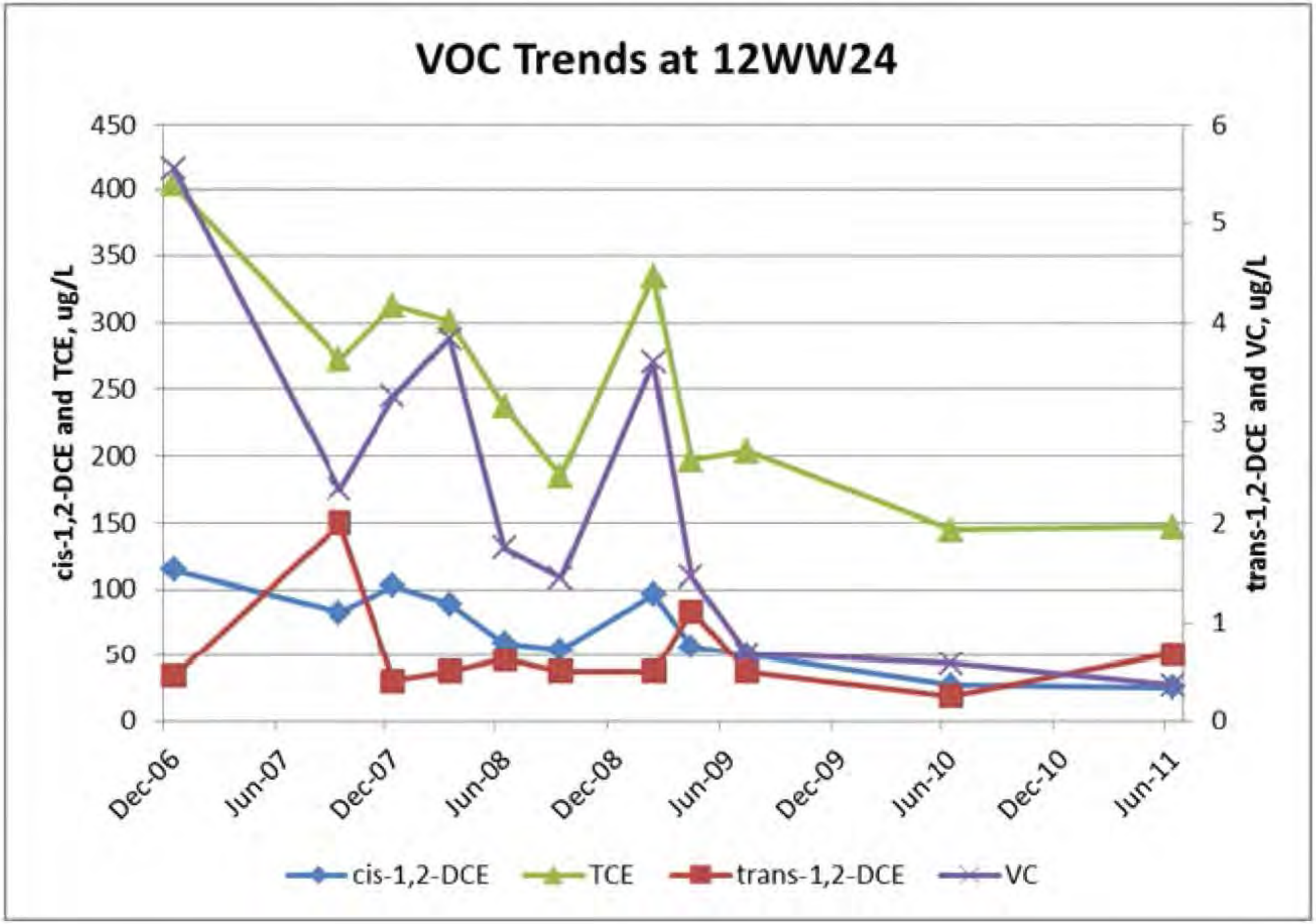
AECOM

Figure D3-1
2009 Groundwater Contamination Plume Map
LHAAP-12
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

January 2013

APPENDIX D4: Groundwater Time Trend Analysis



AECOM

Figure D4-1
VOC Trends at 12WW4
LHAAP-12
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

January 2013

APPENDIX D5: Five-Year Review Site Inspection Checklist

FIVE-YEAR REVIEW SITE INSPECTION CHECKLIST

Information may be completed by hand and attached to the five-year review report as supporting documentation of site status. "N/A" refers to "not applicable."

I. SITE INFORMATION

Site Name: Longhorn Army Ammunition Plant Site: LHAAP-012 (Sanitary Landfill)	Date of Inspection: Dec. 17, 2012
Location and Region: Karnack, TX; EPA Region 6	**EPA ID: TX6213820529**
Agency, office or company leading the five-year review: AECOM under contract to the U.S. Army	Weather/temperature: Sun, Warm temperatures hi 50's to low 60's °F.

Remedy Includes: (Check all that apply)
☒ Landfill cover/containment
☒ Access controls
☒ Institutional controls
☐ Ground water pump and treatment
NA Surface water collection and treatment
☒ Other – MNA

Attachments: ☐ Inspection team roster attached
Inspection Team Members: David D. Gammans, Gretchen McDonnell, Dave Wacker
☐ Site map attached

II. INTERVIEWS (Check all that apply)

	Title	Date
1. O&M Site Manager Name, Affiliation: Scott Beesinger	O&M Site Manager	Dec. 20, 2012

Interviewed: ☐ by mail ☒ at office ☐ by phone Phone no. (903)217-9954
Problems, suggestions: ☒ Report attached (Refer to Appendix I)

	Title	Date
2. O&M Staff Name, Affiliation: Ray Wagner	O&M Staff	Dec. 20, 2012

Interviewed: ☐ by mail ☒ at office ☐ by phone Phone no. (903)679-3448
Problems, suggestions: ☐ Report attached

II. INTERVIEWS (continued)

3. Local regulatory authorities and response agencies (i.e.; State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.). Fill in all that apply.

Agency
Contact ______ ______ ______ ______
Name Title Date Phone no.

Problems, suggestions: ☒ Report attached (Refer to Appendix I)______

Agency______
Contact______ ______ ______ ______
Name Title Date Phone no.

Problems, suggestions: ☒ Report attached (Refer to Appendix I)

4. Other interviews (optional) ☒ Report attached (Refer to Appendix I)

1.
2.
3.
4.
5.

III. ONSITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. O&M Documents

☒ O&M Manual (see below)	☒ Readily available	☒ Up to date	☐ N/A
☒ As-built drawings	☒ Readily available	☒ Up to date	☐ N/A
☒ Maintenance logs	☒ Readily available	☒ Up to date	☐ N/A

Remarks:

2. Site-Specific Health and Safety Plan	☒ Readily available	☒ Up to date	☐ N/A
☒ Contingency plan/emergency response plan	☒ Readily available	☒ Up to date	☐ N/A

Remarks:

III. ONSITE DOCUMENTS & RECORDS VERIFIED (continued)

3. O&M and OSHA Training Records ☒ Readily available ☒ Up to date ☐ N/A

Remarks: ________________

4. Permits and Service Agreements

☐ Air discharge permit	☐ Readily available	☐ Up to date	☒ N/A
☐ Effluent discharge	☐ Readily available	☐ Up to date	☒ N/A
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	☒ N/A
☐ Other permits	☐ Readily available	☐ Up to date	☒ N/A

Remarks:

5. Gas Generation Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

6. Settlement Monument Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

7. Ground Water Monitoring Records ☒ Readily available ☒ Up to date ☐ N/A

Remarks: Aecom electronic database, monthly and quarterly reports

8. Leachate Extraction Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

9. Discharge Compliance Records

☒ Air	☒ Readily available	☐ Up to date	☐ N/A
☒ Water (effluent)	☒ Readily available	☐ Up to date	☐ N/A

Remarks: Monitoring per the 2007 Sampling and Analysis Plan, Groundwater Treatment Plant and Well Fields (Shaw, 2007). Records maintained at GWTP. Quarterly Evaluation Reports maintained in Department of Army, Administrative Record.

10. Daily Access/Security Logs ☒ Readily available ☒ Up to date ☐ N/A

Remarks: Remarks: Daily Sign In Sheet at Groundwater Treatment Plant. Gated fence around landfill perimeter. Access road to Groundwater Treatment Plant is gated with code key for entry. Warning signs posted at the gate and on perimeter fence. Log maintained for access.

IV. O&M COSTS

1. O&M Organization

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☒ Other (Example: Contractor for U.S. Army Corps of Engineers)

(Please see appropriate sections of the Five-Year Review Report (2013) for cost information)

2. O&M Cost Records

☐ Readily available ☐ Up to date
☒ Funding mechanism/agreement in place
Original O&M cost estimate ___________ ☐ Breakdown attached

Total annual cost by year for review period, if available

From _________ Date	to____ Date	_____ Total cost	☐ Breakdown attached
From __ Date	to____ Date	_____ Total cost	☐ Breakdown attached
From __ Date	to______ Date	______ Total cost	☐ Breakdown attached
From _________ Date	to______ Date	_____ Total cost	☐ Breakdown attached
From __ Date	to______ Date	_____ Total cost	☐ Breakdown attached

3. Unanticipated or Unusually High O&M Costs During Review Period

Describe costs and reasons:

1.
2.
3.___
4.___
5.___

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. Fencing damaged ☐ Location shown on map ☒ Gates secure ☐ N/A

Remarks: Restricted Landfill Area fenced. Fencing Complete Around Landfill Perimeter. Good to Excellent Condition. No Breeches in Barbed Wire.

B. Other Access Restrictions

1. Signs and other security measures ☐ Location shown on map ☐ N/A

Remarks: Signage on fencing and gate around landfill perimeter.

C. Institutional Controls

1. Implementation and enforcement

Site conditions imply ICs not properly implemented ☐ Yes ☒ No ☐ N/A

Site conditions imply ICs not being fully enforced ☐ Yes ☒ No ☐ N/A

Type of monitoring (e.g., self-reporting, drive by) Self-reporting, Drive by during most work days.

Frequency

Responsible party/agency U.S. Army

Contact

Name	Title	Date	Phone no.
Ms. Rose M. Zeiler (PhD)	Site Manager	NA	(479)635-0110

Reporting is up-to-date ☐ Yes x No ☐ N/A

Reports are verified by the lead agency ☐ Yes ☐ No ☐ N/A

Specific requirements in deed or decision documents have been met ☒ Yes ☐ No ☐ N/A

Violations have been reported ☐ Yes ☐ No ☒ N/A

Other problems or suggestions: ☐ Report attached

2013 LUC Plan shows last inspection dated 2011

2. Adequacy ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A

Remarks: All construction activities at the Base must also be cleared by the environmental group to address any potential exposure issues.

D. General

1. Vandalism/trespassing ☐ Location shown on site map ☒ No vandalism evident

Remarks:

V.D ACCESS AND INSTITUTIONAL CONTROLS (continued)

2. Land use changes on site ☐ N/A
Remarks: None.

3. Land use changes off site ☐ N/A
Remarks:__ None, Caddo Lake National Wildlife Refuge

VI. GENERAL SITE CONDITIONS

A. Roads ☒ Applicable ☐ N/A

1. Roads damaged ☐ Location shown on site map ☒ Roads adequate ☐ N/A
Remarks:

B. Other Site Conditions
Remarks: General Landfill Condition is Excellent.

VII. LANDFILL COVERS ☒ Applicable ☐ N/A

A. Landfill Surface

1. Settlement (Low spots) ☐ Location shown on site map ☐ Settlement not evident
Arial extent Depth

Remarks: Few Subsidence Areas Marked with flagging: Central ~10'X12', West Edge three small areas one ~ 10X20' and two combined at ~8'X40'. North End ~40'X40', Northwest Mower ruts ~10'X30'. Most areas ~ 1 to 1.5 ft deep. All areas surveyed for GPS coordinates.

2. Cracks ☐ Location shown on site map ☒ Cracking not evident
Lengths Widths Depths
Remarks:

3. Erosion ☐ Location shown on site map ☐ Erosion not evident
Arial extent Depth
Remarks: Minor washout of surface soil and grasses on east side of landfill.

VII.A LANDFILL COVERS (continued)

4. Holes ☐ Location shown on site map ☐ Holes not evident
Arial extent Depth
Remarks: One old, former burrow noticed along east edge fence line.

5. Vegetative Cover ☒ Grass ☐ Cover properly established ☐ No signs of stress
☐ Trees/Shrubs (indicate size and locations on a diagram)
Remarks: No trees/shrubs in fenced landfill. Grasses regularly mowed appear as natural cover.

6. Alternative Cover (armored rock, concrete, etc.) x N/A
Remarks:

7. Bulges ☐ Location shown on site map ☒ Bulges not evident
Arial extent Depth
Remarks:

8. Wet Areas/Water Damage ☒ Wet areas/water damage not evident

☐ Wet areas	☐ Location shown on site map	☐ Arial extent
☐ Ponding	☐ Location shown on site map	☐ Arial extent
☐ Seeps	☐ Location shown on site map	☐ Arial extent
☐ Soft subgrade	☐ Location shown on site map	☐ Arial extent

Remarks:

9. Slope Instability ☐ Slides ☐ Location shown on site map ☒ No evidence of slope instability
Arial extent
Remarks:

B. Benches ☐ Applicable ☒ N/A

1. Flows Bypass Bench ☐ Location shown on site map ☒ N/A or okay
Remarks:

VII.B LANDFILL COVERS (continued)		
2. Bench Breached Remarks:	☐ Location shown on site map	☒ N/A or okay
3. Bench Overtopped Remarks:	☐ Location shown on site map	☒ N/A or okay
C. Letdown Channels	☐ Applicable	☒ N/A
(Channel lined with erosion control mats & rip-rap that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)		
1. Settlement Arial extent Remarks: As Noted Minor Subsidence Areas in Section A 1 Above.	☐ Location shown on site map Depth	☐ No evidence of settlement
2. Material Degradation Material type Remarks:	☐ Location shown on site map Arial extent	☒ No evidence of degradation
3. Erosion Arial extent Remarks: As Noted Minor Erosion in Section A 3 Above.	☐ Location shown on site map Depth	☐ No evidence of erosion
4. Undercutting Arial extent Remarks:	☐ Location shown on site map Depth	☒ No evidence of undercutting
5. Obstructions Type ☐ Location shown on site map Size Remarks:	Arial extent	☒ No obstructions
6. Excessive Vegetative Growth ☒ No evidence of excessive growth ☐ Vegetation in channels does not obstruct flow ☐ Location shown on site map Remarks:	Type Arial extent	

VII. LANDFILL COVERS (continued)

D. Cover Penetrations ☐ Applicable ☒ N/A

1. Gas Vents ☐ Active ☐ Passive
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs maintenance ☒ N/A
Remarks:

2. Gas Monitoring Probes
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs O&M ☒ N/A
Remarks:

3. Monitoring Wells (within surface area of landfill)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs O&M ☒ N/A
Remarks: Could not locate five Monitoring Wells in landfill shown on older Site Maps.

4. Leachate Extraction Wells
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs O&M ☒ N/A
Remarks:

5. Settlement Monuments ☐ Located ☐ Routinely surveyed ☒ N/A
Remarks:

E. Gas Collection and Treatment ☐ Applicable ☒ N/A

1. Gas Treatment Facilities ☒ N/A
☐ Flaring ☐ Thermal destruction ☐ Collection for reuse
☐ Good condition ☐ Needs Maintenance
Remarks:

2. Gas Collection Wells, Manifolds, and Piping ☒ N/A
☐ Good condition ☐ Needs Maintenance
Remarks:

3. Gas Monitoring Facilities (e.g., gas monitoring of adjacent homes or buildings) ☒ N/A
☐ Good condition ☐ Needs Maintenance
Remarks:

VII. LANDFILL COVERS (continued)			
F. Cover Drainage Layer		☐ Applicable	☒ N/A
1. Outlet Pipes Inspected Remarks:		☐ Functioning	☒ N/A
2. Outlet Rock Inspected Remarks:		☐ Functioning	☒ N/A
G. Detention/Sedimentation Ponds		☐ Applicable	☒ N/A
1. Siltation Remarks:	Arial extent Siltation not evident	Depth	☐ N/A
2. Erosion Remarks:	Arial extent Erosion not evident	Depth	
3. Outlet Works Remarks:	☐ Functioning	☐ N/A	
4. Dam Remarks:	☐ Functioning	☐ N/A	
H. Retaining Walls	☐ Applicable	☒ N/A	
1. Deformations Horizontal displacement Rotational displacement Remarks:	☐ Location shown on site map	Vertical displacement	☐ Deformation not evident
2. Degradation Remarks:	☐ Location shown on site map		☐ Degradation not evident

VII. LANDFILL COVERS (continued)			
I.	**Perimeter Ditches/Off-Site Discharge**	☒ Applicable	☐ N/A
1.	**Siltation** Arial extent Remarks:	☐ Location shown on site map Depth	☒ Siltation not evident
2.	**Vegetative Growth** ☒ Vegetation does not impede flow Arial extent Remarks:	☐ Location shown on site map Type	☐ N/A
3.	**Erosion** Arial extent Remarks:	☐ Location shown on site map Depth	☒ Erosion not evident
4.	**Discharge Structure** Remarks:	☐ Functioning	☒ N/A

VIII. VERTICAL BARRIER WALLS		☐ Applicable	☒ N/A
1.	**Settlement** Arial extent Remarks:	☐ Location shown on site map ☐ Depth	☐ Settlement not evident
2.	**Performance Monitoring** ☐ Performance not monitored Frequency Head differential Remarks:	Type of monitoring	☐ Evidence of breaching

IX. GROUNDWATER/SURFACE WATER REMEDIES		☒ Applicable; MNA	☐ N/A
A.	**Groundwater Extraction Wells, Pumps, and Pipelines**	☐ Applicable	☒ N/A
1.	**Pumps, Wellhead Plumbing, and Electrical** ☐ Good condition ☐ All required wells located Remarks:	☐ Needs maintenance	☒ N/A

IX. GROUNDWATER/SURFACE WATER REMEDIES ☒ Applicable, MNA ☐ N/A

2. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances
☐ Good condition ☐ Needs maintenance
Remarks:

3. Spare Parts and Equipment
☒ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks:

B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ☒ N/A

1. Collection Structures, Pumps, and Electrical
☐ Good condition ☐ Needs maintenance
Remarks:

2. Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances
☐ Good condition ☐ Needs maintenance
Remarks:

3. Spare Parts and Equipment
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks:

C. Treatment System ☐ Applicable ☒ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☐ Carbon adsorbers
☐ Filters
☐ Additive (e.g., chelation agent, flocculent)
☐ Others
☐ Good condition ☐ Needs maintenance
☐ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☐ Equipment properly identified
☐ Quantity of ground water treated annually
☐ Quantity of surface water treated annually
Remarks:

IX.C. GROUND WATER/SURFACE WATER REMEDIES (continued)

2. Electrical Enclosures and Panels (Properly rated and functional)
☒ N/A ☐ Good condition ☐ Needs maintenance
Remarks:

3. Tanks, Vaults, Storage Vessels
☒ N/A ☐ Good condition ☒ Proper secondary containment ☐ Needs maintenance
Remarks:

4. Discharge Structure and Appurtenances
☒ N/A ☐ Good condition ☐ Needs maintenance
Remarks:

5. Treatment Building(s)
☒ N/A ☐ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks:

6. Monitoring Wells (Pump and treatment remedy)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ All required wells located ☐ Needs maintenance ☒ N/A
Remarks: Site Monitoring Well Maintenance Planned.

D. Monitoring Data

1. Monitoring Data
☒ Is routinely sampled on time x Is of acceptable quality

2. Monitoring Data Suggests
☐ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining (with minor exceptions, see text of Five-Year Review report

E. Monitored Natural Attenuation ☒ Applicable ☐ N/A

1. Monitoring Wells (Natural attenuation remedy)
☐ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☐ Good condition
☐ All required wells located ☒ Needs maintenance ☐ N/A
Remarks:

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

The final remedy at LHAAP-12 includes LUCs and MNA combined with capping. The cap is providing long-term protection by minimizing the infiltration of water into the landfill. LUCs consist of cap protection provisions and groundwater use restrictions. LUCs are functioning to mitigate potential risks to human health and the environment by restricting access to the contaminated media. Monitoring well results indicate contaminant concentrations are decreasing over time as a result of natural attenuation. MNA appears to be effective as indicated by the presence of reductive dechlorination daughter products.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

The cap is functioning as designed and needs only routine maintenance. The caps are maintained and inspected in accordance with the RCRA requirements. Maintenance procedures are presently under revision.

XI. OVERALL OBSERVATIONS (continued)

C. Early Indicators of Potential Remedy Failure

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future.

Unexpected repairs since the last five-year review were minimal. Some minor erosion issues were observed and these have been adequately addressed both in the past as well as the present. No indicators of potential failure were observed during this five-year review.

D. Opportunities for Optimization

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

1. None
2.
3.
4.

Individual Site Notes – Field Reconnaissance

Longhorn Army Ammunition Plant, Karnack, TX.

2013 Five Year Review

Site: LHAAP-012 **Date: 12/17/12**

Field Team: Dave Wacker, Gretchen McDonnell, Dave Gammans

Findings:	Remedy:
1. Unlocked Gate:	Needs New Lock, Securing
2. Numerous Subsidence Areas Marked with flagging:	GPS Coordinates Recorded
a. Central ~10'X12'	
b. West Edge three small areas ~10X20' and two combined at ~8'X40'	
c. North End ~40'X40'	
d. Northwest Mower ruts ~10'X30'.	
Most areas ~ 1 to 1.5 ft deep.	Backfill, Tamper, Regrade, Vegetate
3. Minor washout surface soil and grasses on east edge.	Grade, Vegetate
4. East Edge fence line old, former animal burrow.	Check for activity, backfill and grade
5. Monitoring Well Identification, Condition – Out of date	Confirm IDs, repainting, remarking, some locks, hinge repair (see well list)

Site: LHAAP-016 **Date: 12/17/12**

Field Team: Dave Wacker, Gretchen McDonnell, Dave Gammans

Findings:	Remedy:
1. Access Unrestricted @ Gate:	Needs Barbed Wire to limit access around gate
2. Signage Missing Along Fence line	Replace
3. Few, Small Subsidence Areas Marked with flagging	
a. Central, West 30'X30'	
b. Central, North ~40X10'	
Areas ~ 0.5 ft deep.	Backfill, Tamper, Regrade, Vegetate
4. Minor erosion surface soil, sparse vegetation esp.west edge	Grade, Vegetate
a. West 20'X15' and 50'X30'	
b. East 15'X30' and 10'X50'	
c. Northeast, Slight	
d. North, Slight	
5. Animal burrow. East Central near swale	Check for activity, backfill and grade
6. Monitoring Well Identification, Condition	Confirm IDs, repainting, remarking, growth clearing, some pad repairs, some locks, hinge repair (see well list)

Site: LHAAP-018/ 024 **Date: 12/19 and 20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Unlocked Gate	Needs New Lock, Securing
2. Gate Signage Illegible	Replace with new signs
3. Signage Missing Along Fence line	Replace
4. Few areas of Fence Have Excessive Vegetation	Clearing / Maintenance
5. Monitoring Well Identification, Condition – Out of date	Inspection, Confirm IDs, Repainting, Remarking, Locks, Repair or Abandon as needed

Site: Groundwater Treatment Plant (GWTP) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Rust Corrosion on Activated Carbon Vessels	Recondition, Repaint
2. Rust Corrosion on PK200B Tank	Recondition, Repaint
3. Rust Residue Below PK140 Influent Holding Tank Flange	Recondition, Repaint
4. System Optimization	Engineering Review
5. Level Probe Hydrochloric Acid Tank	Needs Engineering Review, Repair

Site: Former Pistol Range (LHAAP-004-R-01) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Daily Access/Security Logs	Review LUC Management Plan and Determine Fish and Wildlife Service and/or US Army Responsibility
2. Missing Signage, Gate Access	Review Plan As Above
3. Former Monitoring Well Abandonment	Research, Confirm, Possible Search

Site: Former Acid Plant (LHAAP-049) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Daily Access/Security Logs	Review LUC Management Plan and Determine Fish and Wildlife Service and/or US Army Responsibility
2. Missing Signage, Access	Review Plan As Above
3. Monitoring Wells Identification, Condition	Research, Confirm IDs, Repainting, Remarking, Growth Clearing, Repair or Abandon as needed

APPENDIX D6: Photographs

Photo Log – LHAAP-12

Longhorn Army Ammunition Plant, Karnack, TX.

2013 Five Year Review

Photo #	Date	Site	Description
101_1004.JPG	12/17/12	LHAAP-012	Landfill, Near Entrance Looking North
101_1005.JPG	12/17/12	"	Landfill Surface Looking North (Dave Wacker and Gretchen McDonnell in photo)
101_1006.JPG	12/17/12	"	Landfill Central Area with Mower Tracks and Slight Subsidence
101_1007.JPG	12/17/12	"	Landfill Central Area with Slight Subsidence (clipboard for scale)
101_1008.JPG	12/17/12	"	Landfill North Area with Slight Subsidence (clipboard for scale)
101_1009.JPG	12/17/12	"	Landfill North Area with Slight Subsidence (clipboard for scale)
101_1010.JPG	12/17/12	"	Landfill Central Area with Slight Subsidence (clipboard for scale)
101_1011.JPG	12/17/12	"	Landfill Northwest Area (clipboard and shadow)
101_1012.JPG	12/17/12	"	Landfill West Side Mower Tracks and Slight Washout
101_1013.JPG	12/17/12	"	Animal Burrow Near East Edge Fence (clipboard for scale)
101_1014.JPG	12/17/12	"	Landfill East Edge Bare, Slight Washout Area

Weather: sun, slight wind, temps hi 50's to low 60's °F.

Field Team: David Gammans, Dave Wacker, Gretchen McDonnell

Camera Details: Kodak EasyShare M5350, 16 MP

Completed Site Forms\12-17-2012

Additional Comments:


KEEP OUT
HAZARDOUS SUBSTANCES
NO ENTRE
SUBSTANCIAS PELIGROSAS
12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012

APPENDIX E: LHAAP-16 Supporting Documents

APPENDIX E1: Documents Reviewed

Documents Reviewed for LHAAP-16

Complete Environmental Service, Inc., 2002. *Final Report- Five-Year Review Report- for Sites 18 & 24 (Burning Ground 3), Site 16 (Old Landfill), and Site 12 (Sanitary Landfill) at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, AR 2002 Vol 3 of 4 A, 029146-029297, 2002_1st-5yr_reviewComplEnvService.pdf. August.

OHM Remediation Services, 1998. *Final Construction Completion Report, Interim Remedial Action, Landfills 12 and 16 Cap Construction*. December.

Jacobs Engineering Group, Inc. (Jacobs), 2000. *Remedial Investigation Report for Site 16 Landfill Remedial Investigation and Feasibility Study at Longhorn Army Ammunition Plant, Karnack, Texas*. October.

Jacobs, 2001. *Final Remedial Investigation Report, Group 2 Sites, Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*. April.

Jacobs, 2001. *Final Report - Baseline Risk Assessment: Human Health Evaluation - Volume 1: Report (supplement to the Remedial Investigation Report), for Site 16 Landfill Remedial Investigation and Feasibility Study, at the Longhorn Army Ammunition Plant, Karnack, Texas*. June.

Jacobs, 2002. *Final Feasibility Study for Site 16, Longhorn Army Ammunition Plant, Karnack, Texas*. March.

Plexus Scientific Corp., 2005. *Environmental Site Assessment, Phase I and II Report, Final, Production Areas, Longhorn Army Ammunition Plant, Karnack, Texas*. February.

Shaw, 2007. *Quarterly Evaluation Report, 4th Quarter (October – December) 2006, Groundwater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, Texas*. January.

Shaw, 2007. *Quarterly Evaluation Report, 1st Quarter (January – March) 2007, Groundwater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, Texas*. April.

Shaw, 2007. *Final Addendum 11, Monitored Natural Attenuation Sampling, LHAAP-16, -17, -29, -46, -47, -50, -35A(58), Final Installation-Wide Work Plan, Longhorn Army Ammunition Plant, Karnack, Texas*. May.

Shaw, 2007. *Sampling and Analysis Plan, GWTP and Well Fields. Longhorn Army Ammunition Plant, Karnack, Texas*. July.

Shaw, 2007. *Quarterly Evaluation Report 2nd Quarter (April – June) 2007, Groundwater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, Texas*. August.

Shaw, 2007. *Final Installation-Wide Baseline Ecological Risk Assessment, Volume I, Longhorn Army Ammunition Plant, Karnack, TX*, AR 2007 Vol 10 of 25 A, 00049542 - 00050415, 2007 Final-Instln-Baseline-EcoVol10of25.pdf. November.

Shaw, 2008. *Final Five-Year Review, Second Five-Year Review Report for LHAAP-12, LHAAP-16 and LHAAP-18/24, Longhorn Army Ammunition Plant, Karnack, Texas*, AR 2008 Vol 9 of 9 E, 00070660 - 00070845, Sept 2008 five year review with Comnts+APPS.pdf. September.

Shaw, 2010. *Final Addendum to Final Feasibility Study, LHAAP-16, Longhorn Army Ammunition Plant, Karnack, Texas*. March.

Shaw, 2010. *Draft Final Feasibility Study, LHAAP-18/24, Burning Ground No.3 and Unlined Evaporation Pond.* May

Shaw, 2011. *Draft Final Record of Decision, LHAAP-16, Landfill, Longhorn Army Ammunition Plant, Karnack, Texas*. Prepared for U.S. Army Corps of Engineers, Tulsa District. September.

Shaw, 2011. *Quarterly Evaluation Report 3rd Quarter (July-September) 2011 Groundwater Treatment Plant.* November.

Shaw, 2012. *Quarterly Evaluation Report 2nd Quarter (April-June) 2012 Groundwater Treatment Plant. August.*

Solutions To Environmental Problems, Inc., 2005. *Final Plant-Wide Perchlorate Investigation for the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, AR 2005 Vol 3 of 5 L, 037271 -037509, 2005Perchlorate.pdf. April.

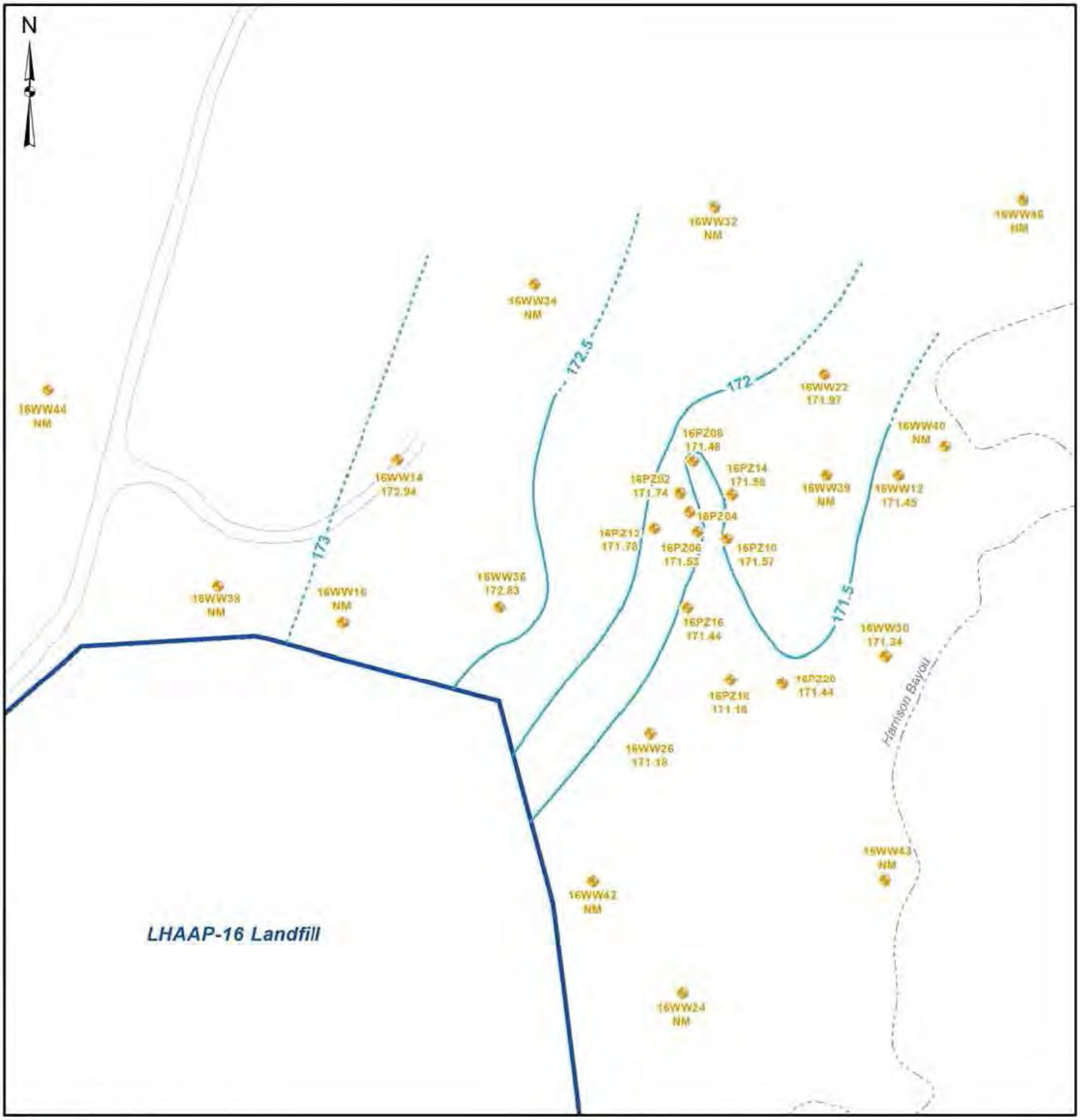
U.S. Army, 1991. *Final Agreement- Federal Facility Agreement Under CERCLA Section 120, Longhorn Army Ammunition Plant, Marshall, Texas*, AR 1991 Vol 1 of D, 004332-004400, 1991Federal Facility Agreement.pdf. September.

U.S. Army, 1995. *LHAAP 12 and 16 Landfills, Longhorn Army Ammunition Plant, Record of Decision, Early Interim Remedial Action*. September.

U.S. Army Corps of Engineers and ALL Consulting (USACE and ALL), 2006, *Final Groundwater Monitoring Report, Sites 12 and 16, Spring 2003, Spring 2004, and Winter 2004, Longhorn Army Ammunition Plant, Texas*, January.

U.S. Environmental Protection Agency, 2001. Office of Emergency and Remedial Response (5204G), *Comprehensive Five-Year Review Guidance*, EPA 540-R-01-007, OSWER No. 9355.7-03B-P. June.

APPENDIX E2: Groundwater Elevation Maps



Legend

- Shallow Monitoring Well
- Groundwater Elevation Contour (Dashed Where Inferred)
- Streams
- Roads
- LHAAP-16 Landfill Fence

Notes:

171.48 Groundwater Elevation (feet above mean sea level)

NM - Not Measured

Source: Record of Decision, 2011.

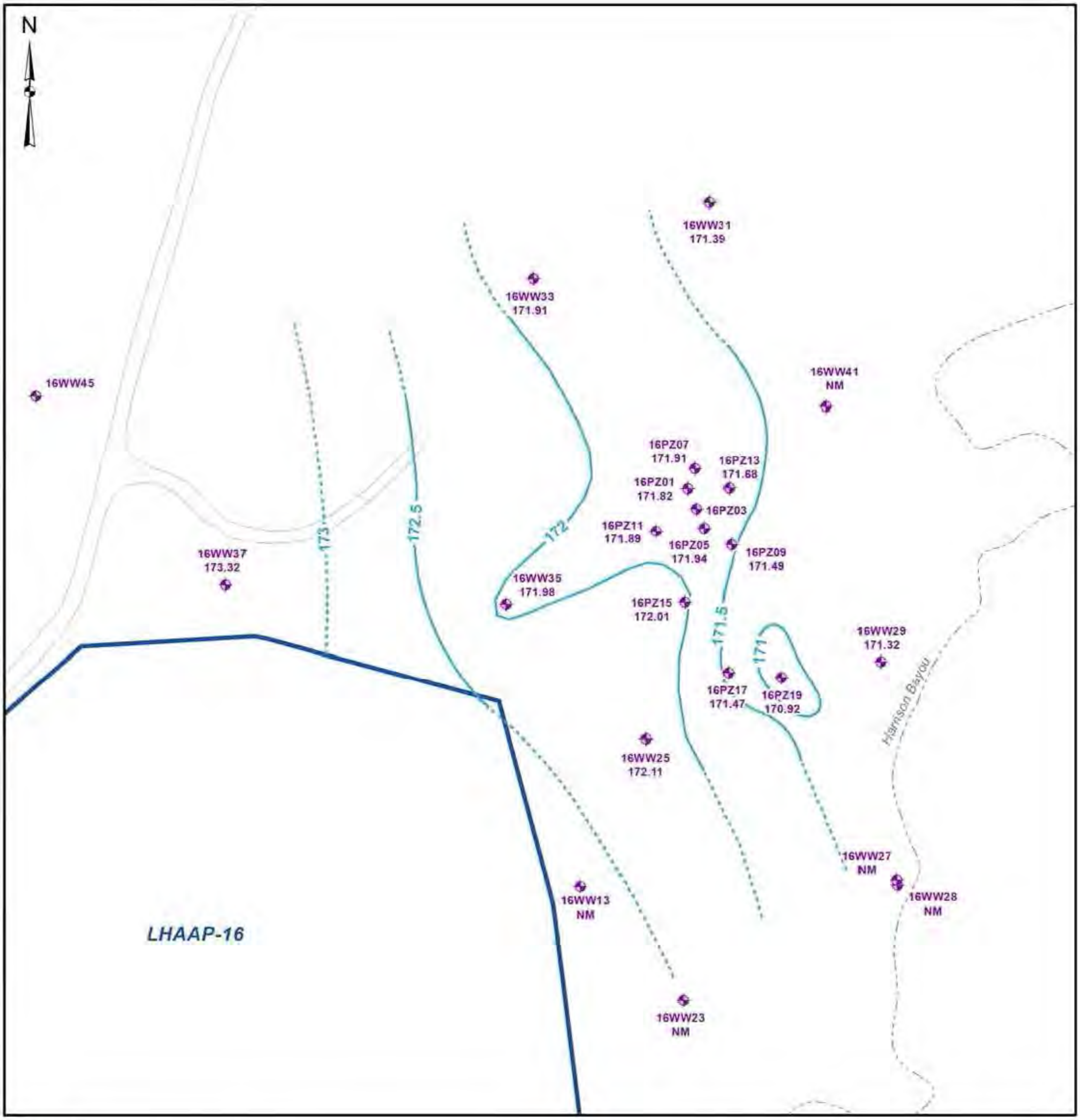
0 85 170 340
Feet

AECOM

Figure E2-1
Groundwater Elevation Map
Shallow Zone - June 2007
LHAAP-16 Five Year Review
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012



Legend

- Intermediate Monitoring Well
- Groundwater Elevation Contour (Dashed Where Inferred)
- Streams
- Roads
- LHAAP-16 Landfill Fence

Notes:

172.11 Groundwater Elevation (feet above mean sea level)

NM - Not Measured

Source: Record of Decision, 2011.

0 85 170 340 Feet

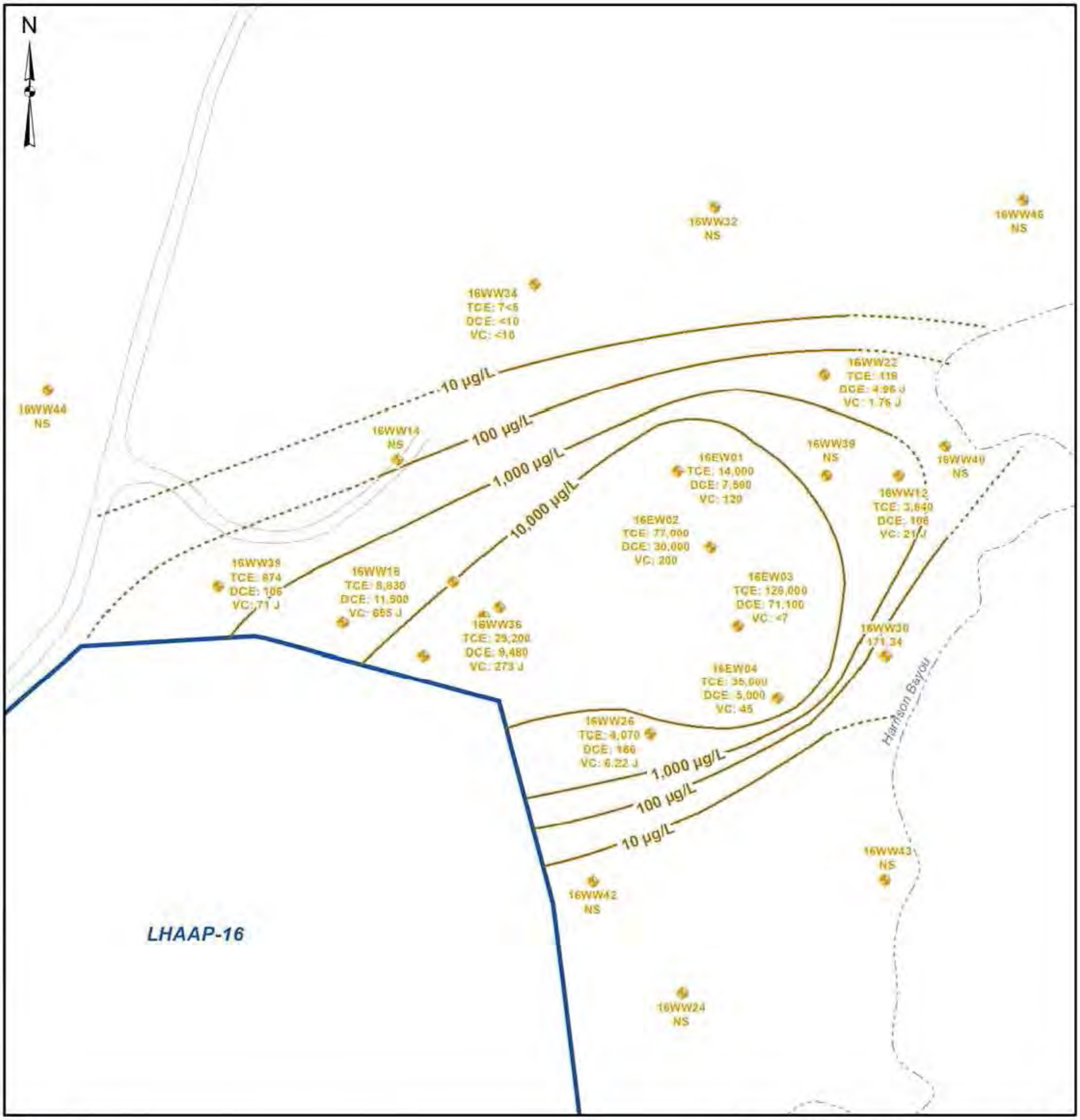
AECOM

Figure E2-2
Groundwater Elevation Map
Intermediate Zone - June 2007
LHAAP-16 Five Year Review
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012

APPENDIX E3: Groundwater/Soil Concentration Maps



Legend

- Shallow Monitoring Well
- TCE Concentration Contour (Dashed Where Inferred)
- Streams
- Roads
- LHAAP-16 Landfill Fence

0 85 170 340 Feet

Notes:
Results are in micrograms per liter (µg/L)
DCE - cis-1,2-Dichloroethene
J - Estimated Value
NS - Not Sampled
TCE - Trichloroethene
VC - Vinyl Chloride
VOC - Volatile Organic Compound

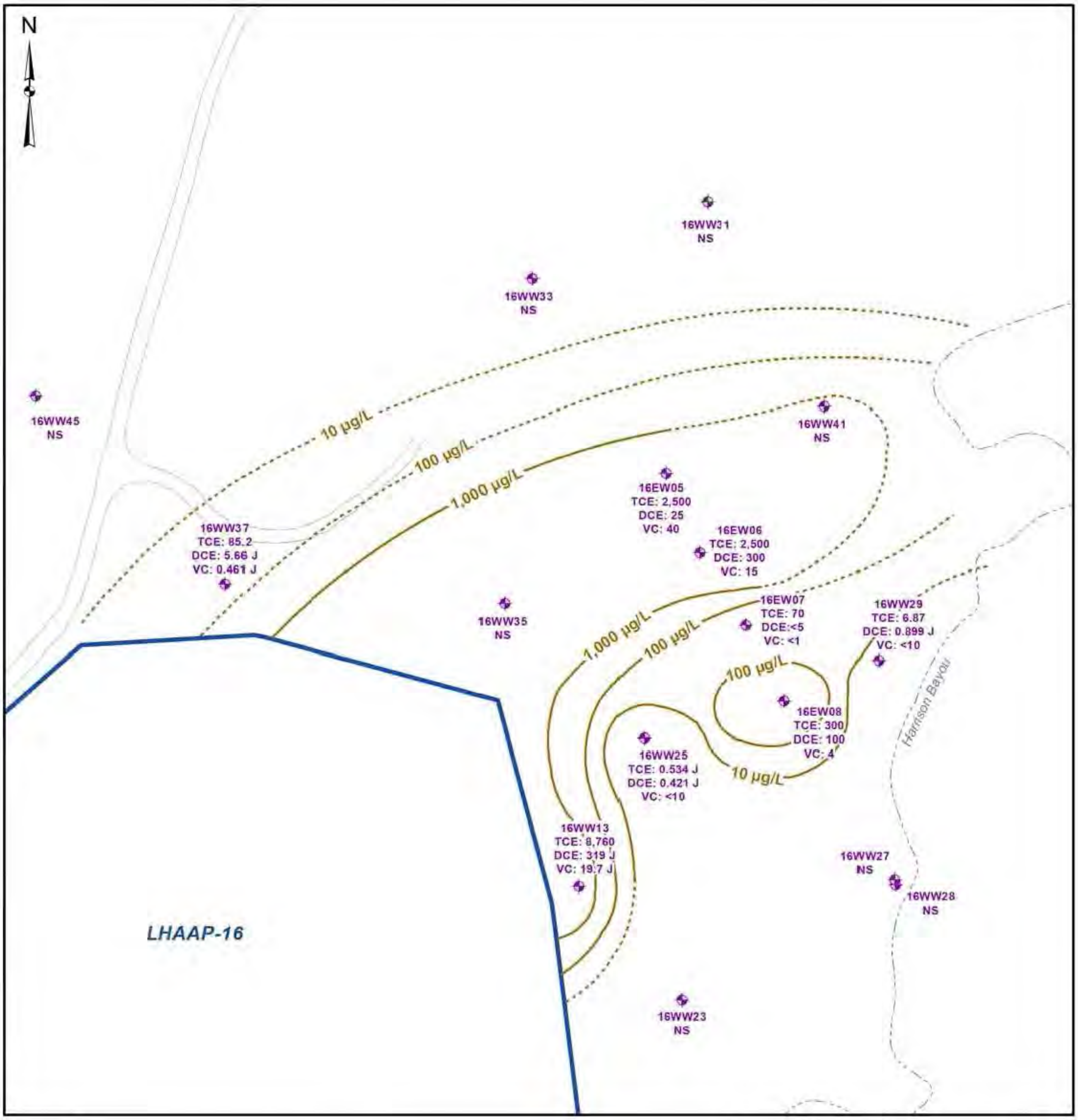
Source: Shaw 2010, Addendum to Final Feasability Study.

AECOM

Figure E3-1
VOCs in Groundwater
Shallow Zone - June 2007
LHAAP-16 Five Year Review
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012



Legend

- Intermediate Monitoring Well
- TCE Concentration Contour (Dashed Where Inferred)
- Streams
- Roads
- LHAAP-16 Landfill Fence

0 85 170 340 Feet

Notes:
Results are in micrograms per liter (µg/L)
DCE - cis-1,2-Dichloroethene
J - Estimated Value
NS - Not Sampled
TCE - Trichloroethene
VC - Vinyl Chloride
VOC - Volatile Organic Compound

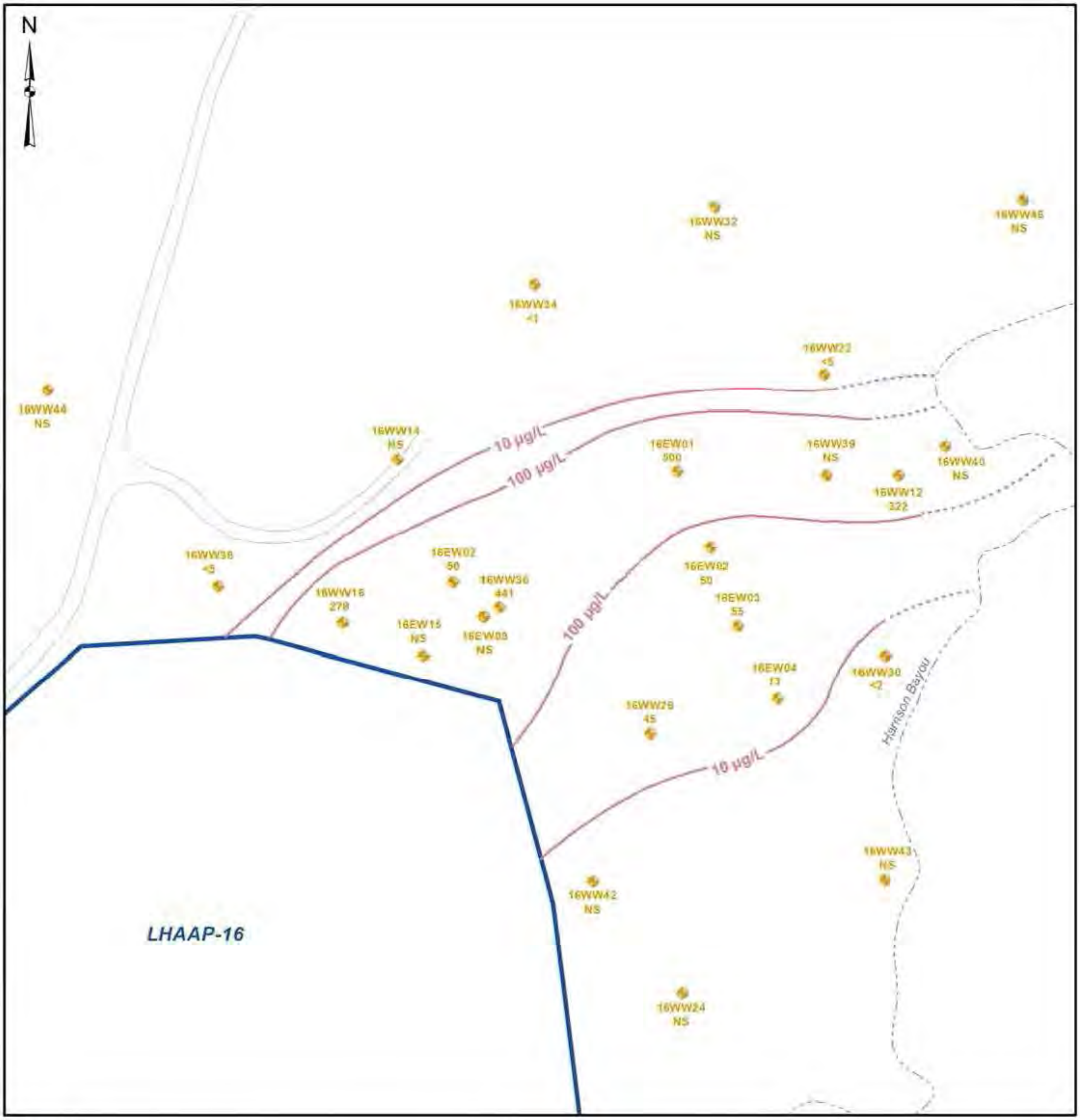
Source: Shaw 2012, Addendum to Final Feasability Study.

AECOM

Figure E3-2
VOCs in Groundwater
Intermediate Zone - June 2007
LHAAP-16 Five Year Review
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012



Legend

Shallow Monitoring Well

Perchlorate Concentration Contour (Dashed Where Inferred)

Streams

Roads

LHAAP-16 Landfill Fence

Notes:
Results are in micrograms per liter (µg/L)
NS - Not Sampled

Source: Shaw 2010, Addendum to Final Feasability Study.

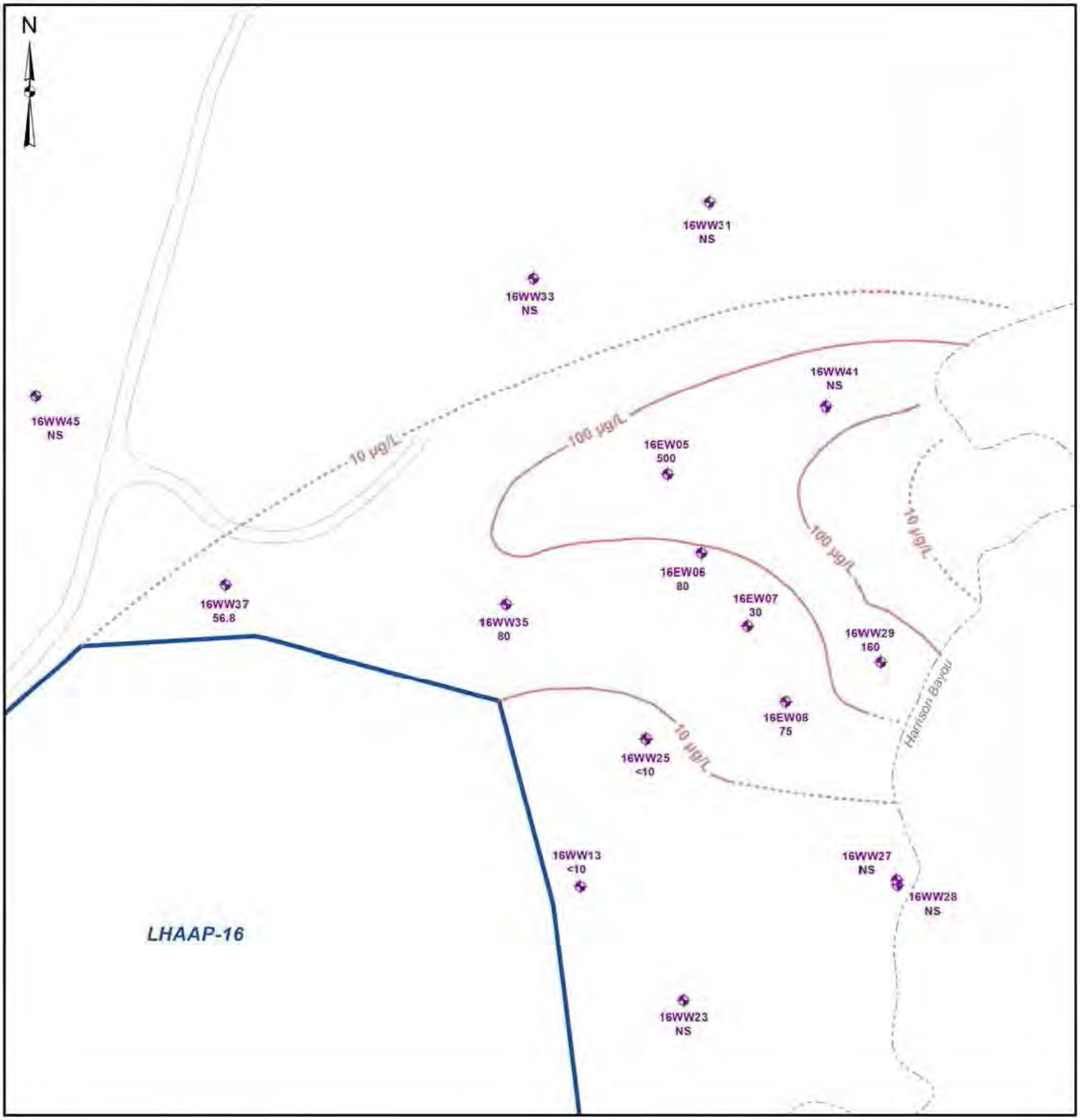
0 85 170 340 Feet

AECOM

Figure E3-3
Perchlorate Concentrations in Groundwater
Shallow Zone - June 2007
LHAAP-16 Five Year Review
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012



Legend

- Intermediate Monitoring Well
- Perchlorate Concentration Contour (Dashed Where Inferred)
- Streams
- Roads
- LHAAP-16 Landfill Fence

Notes:
Results are in micorgrams per liter (µg/L)
NS - Not Sampled

Source: Shaw 2010, Addendum to Final Feasability Study.

0 85 170 340 Feet

AECOM

Figure E3-4
Perchlorate Concentrations in Groundwater
Intermediate Zone - June 2007
LHAAP-16 Five Year Review
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

December 2012

APPENDIX E4: Groundwater Time Trend Analysis

NOTES FOR FIGURES E4-1 through E4-8:

Filled symbols: shallow depth wells

Unfilled symbols: intermediate depth wells

Co-located wells screened at shallow and intermediate depths have symbols that are the same color and shape

For trichloroethene (TCE), a value of 0.4 micrograms per liter (µg/L) indicates the concentration is less than the method detection limit. A method detection limit of 0.36 µg/L was reported for most nondetected cases.

For perchlorate (ClO4), a value of 0.05 micrograms per liter (µg/L) indicates the concentration is less than the method detection limit. This value was used to distinguish nondetects from detections because the method detection limit ranged from of 0.05 – 958 µg/L, which overlapped detected values, which ranged from 0.07 to 5990 µg/L. Nondetected results are also distinguished by orange-filled symbols used in data series that mainly have a different color fill or no fill.

Figure E4-1: TCE Trends in Extraction Wells

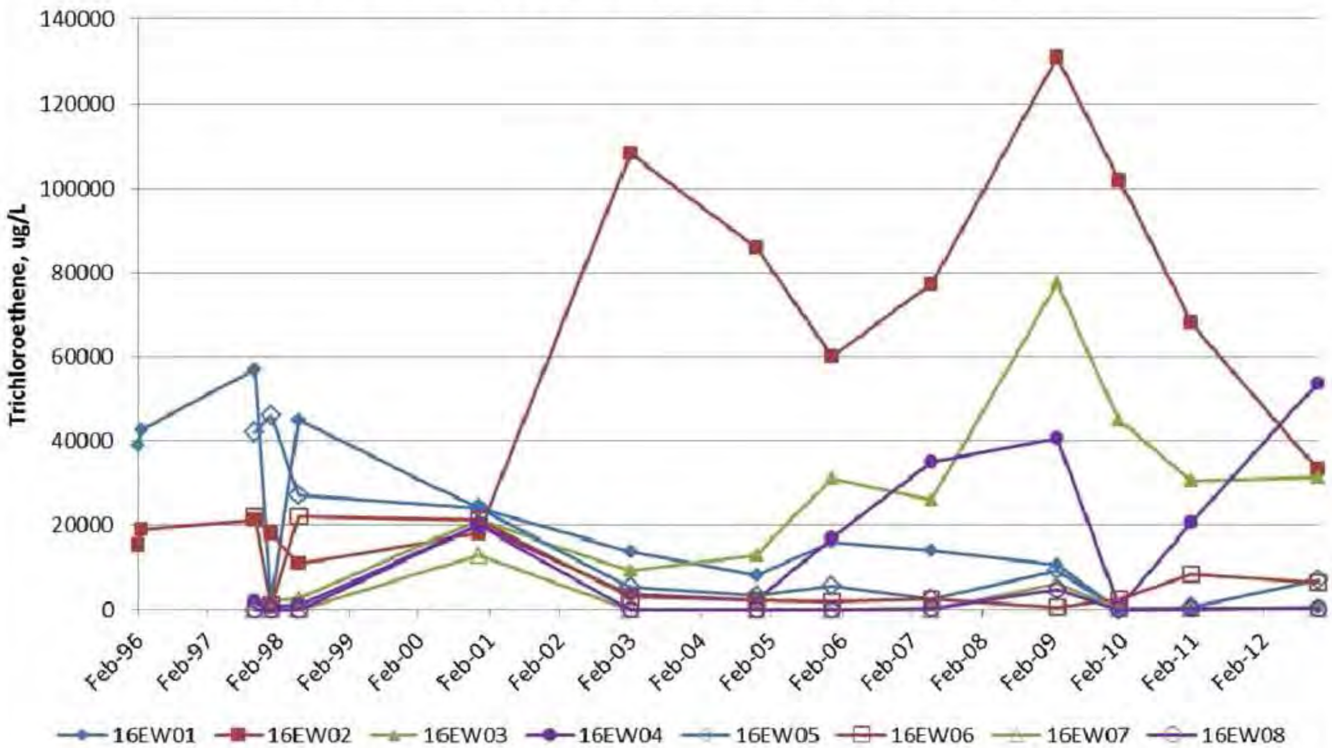


Figure E4-2: TCE Trends in Extraction Wells - Log Scale

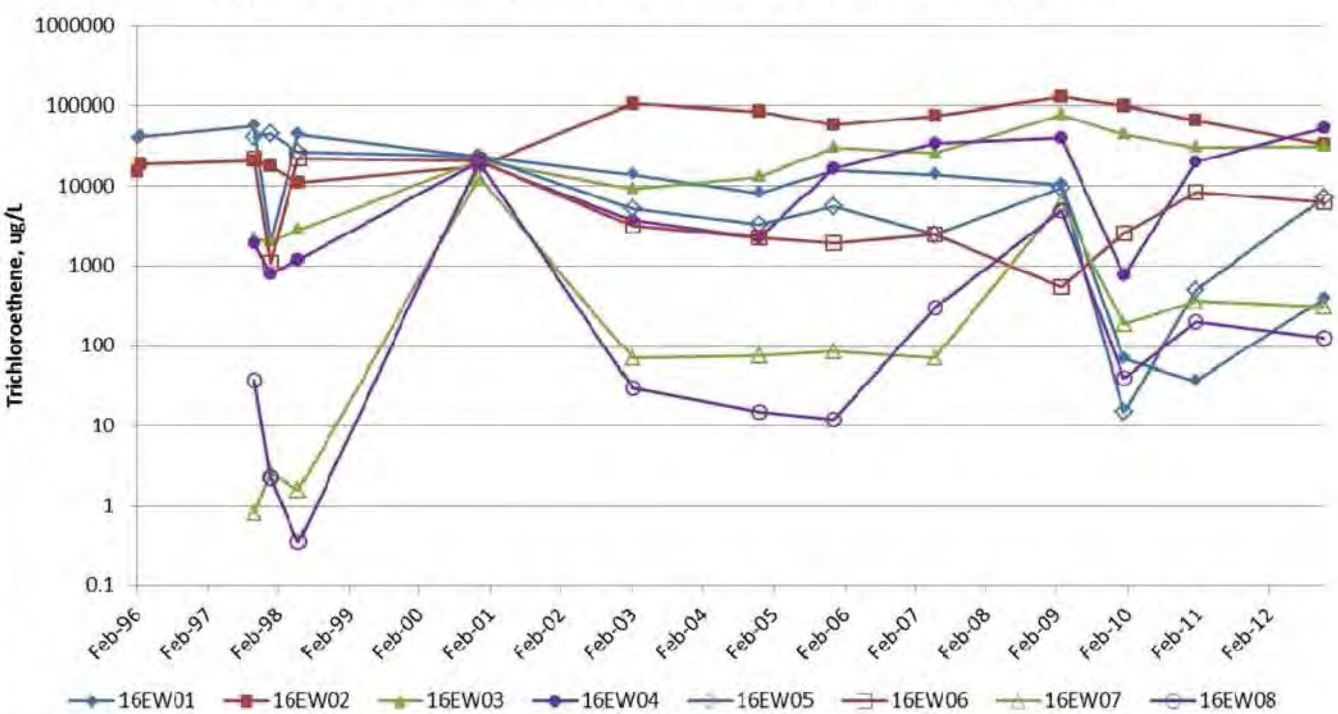


Figure E4-3: TCE Trends in Monitoring Wells Downgradient of Extraction Wells

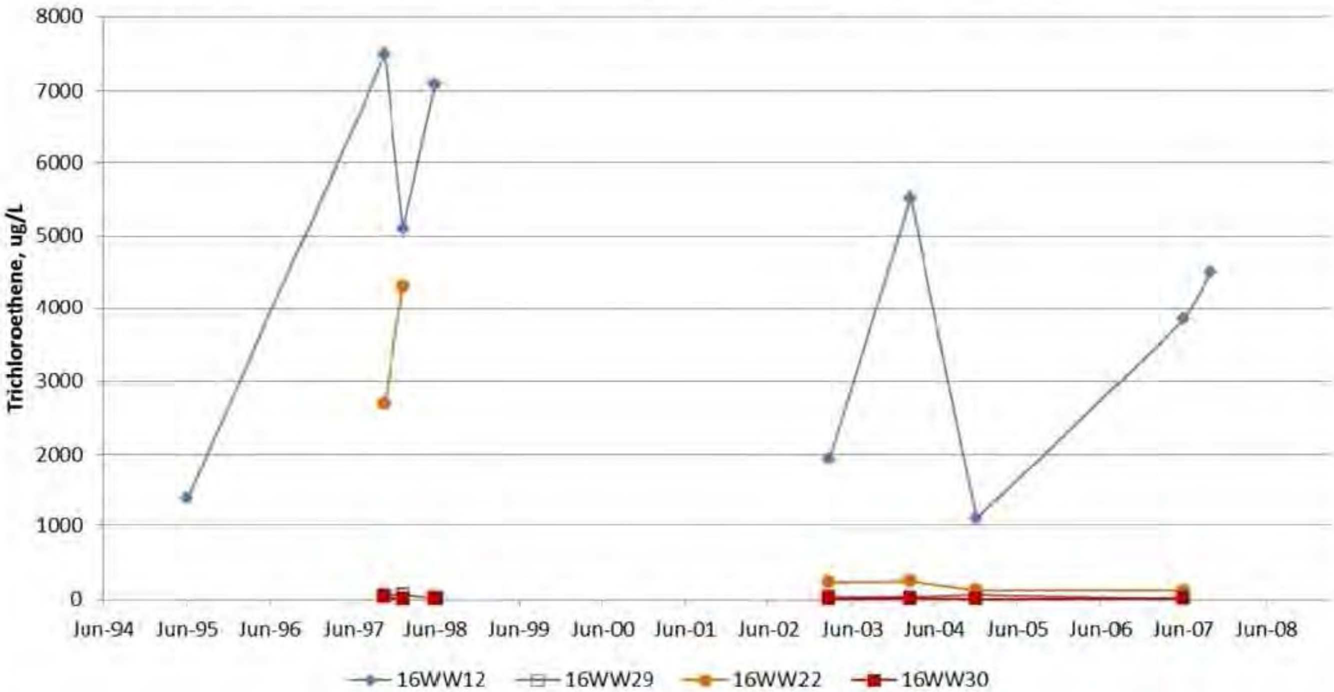
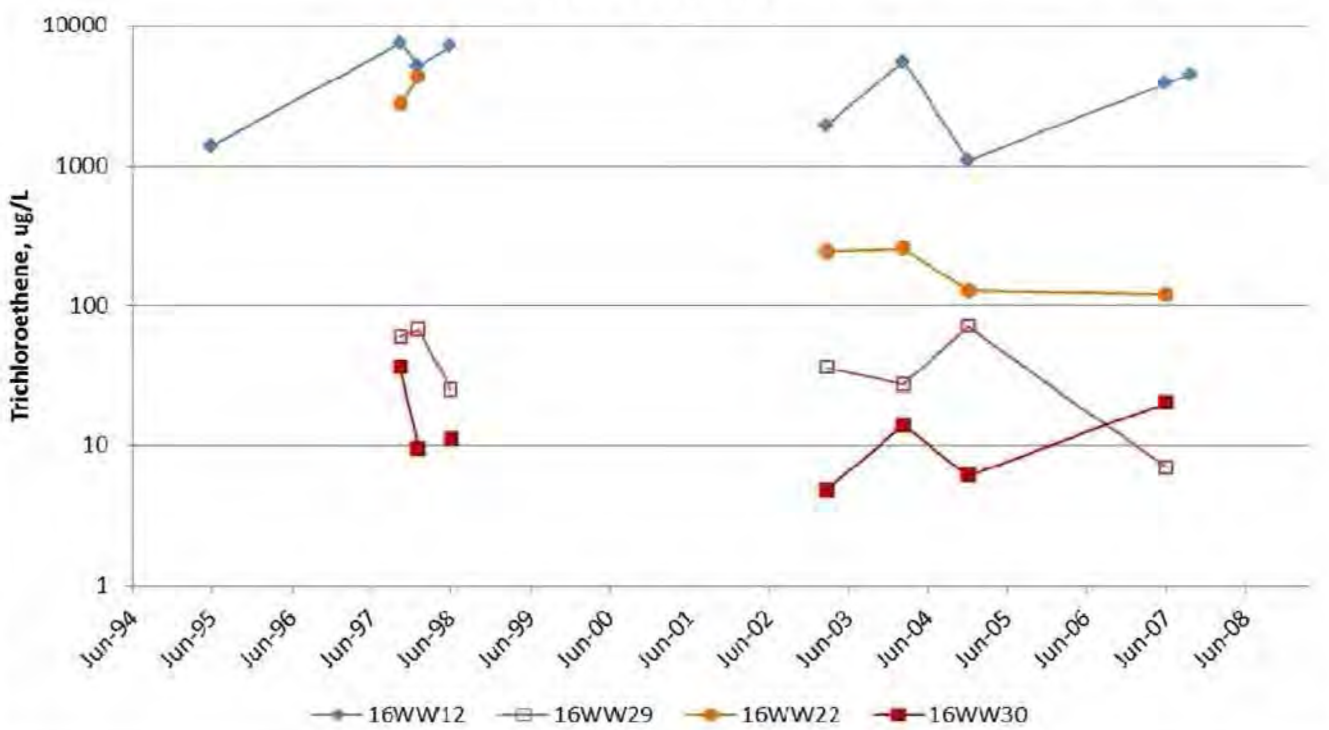


Figure E4-4: TCE Trends in Monitoring Wells Downgradient of Extraction Wells - Log Scale



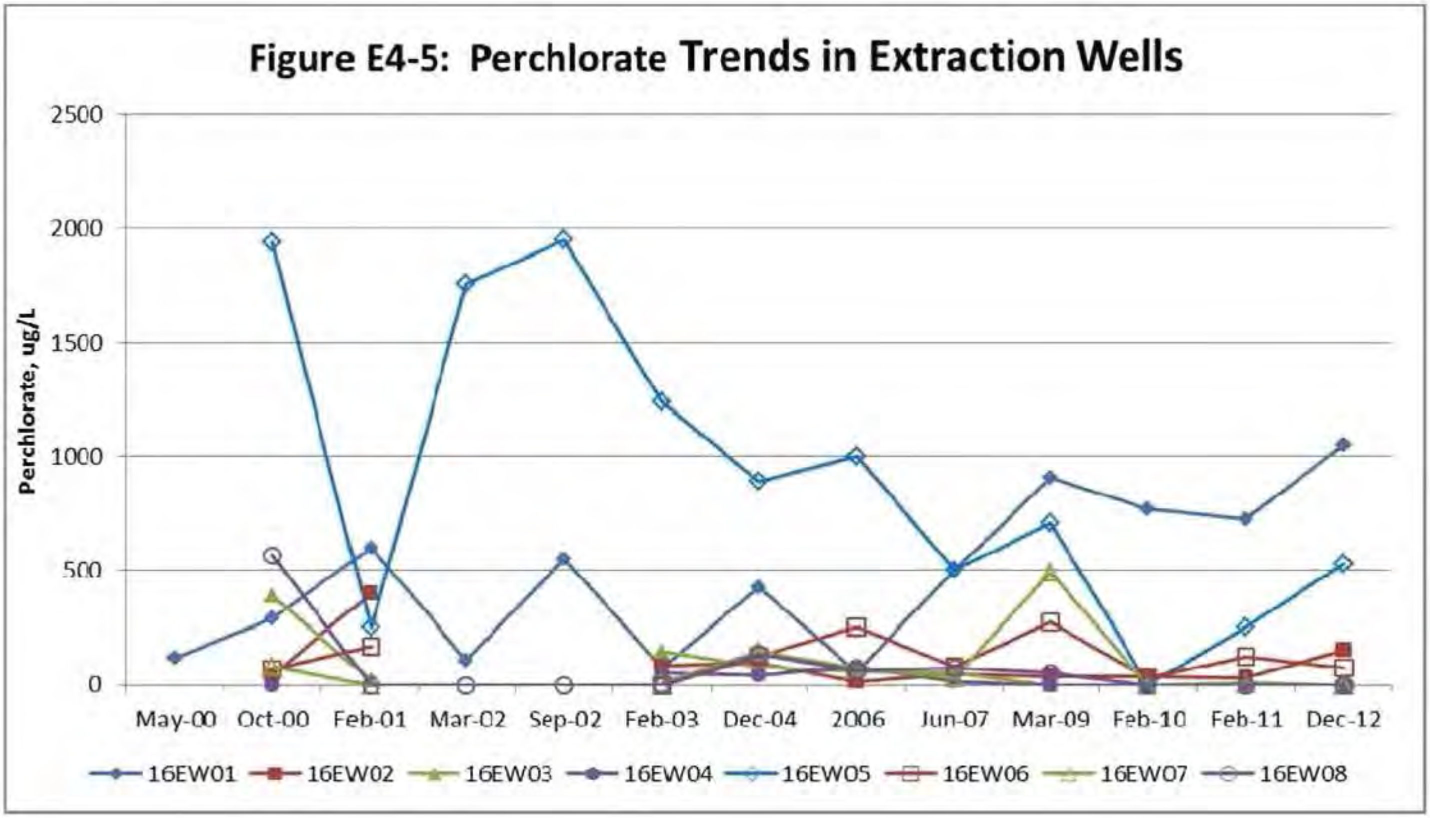


Figure E4-5: Perchlorate Trends in Extraction Wells
Perchlorate, ug/L
2500
2000
1500
1000
500
0
May-00 Oct-00 Feb-01 Mar-02 Sep-02 Feb-03 Dec-04 2006 Jun-07 Mar-09 Feb-10 Feb-11 Dec-12
16EW01 16EW02 16EW03 16EW04 16EW05 16EW06 16EW07 16EW08

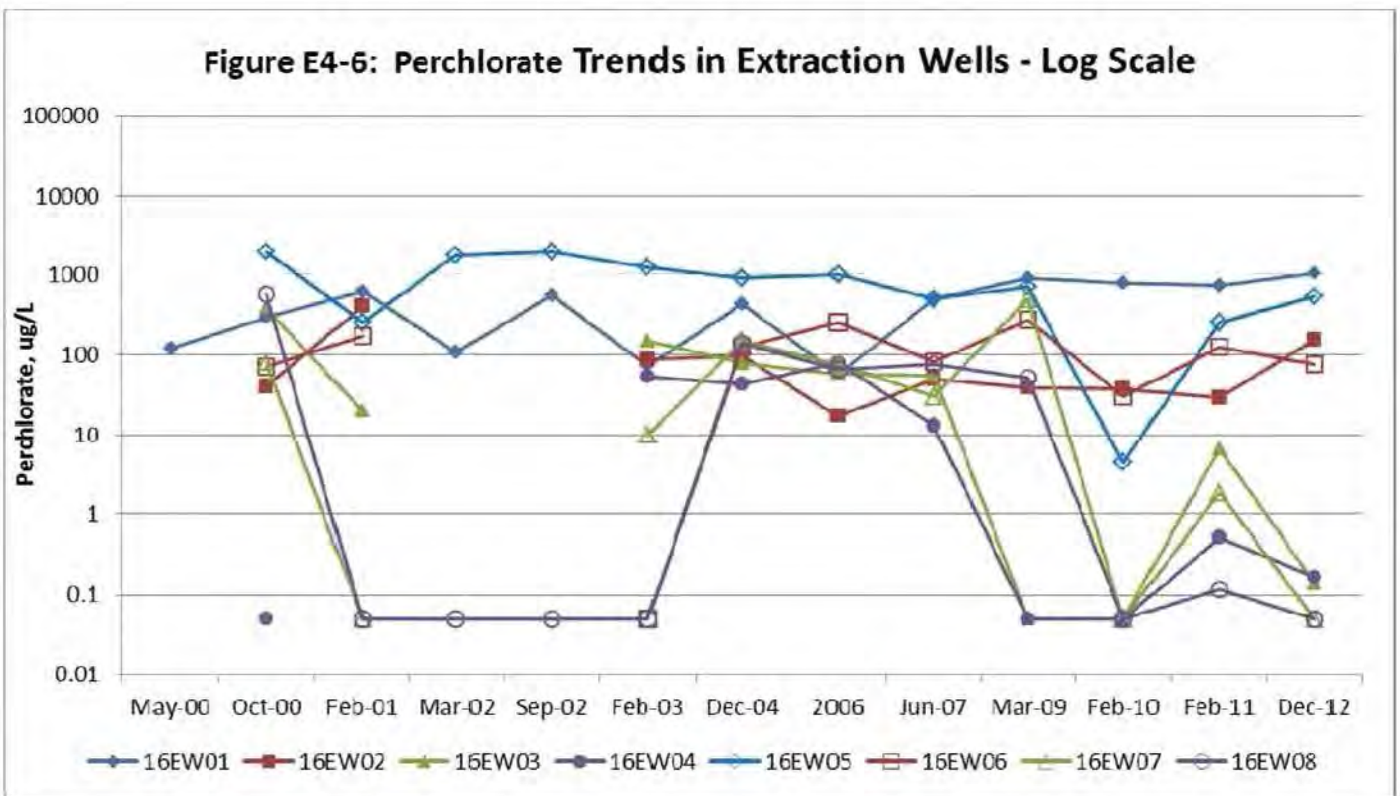


Figure E4-6: Perchlorate Trends in Extraction Wells - Log Scale
Perchlorate, ug/L
100000
10000
1000
100
10
1
0.1
0.01
May-00 Oct-00 Feb-01 Mar-02 Sep-02 Feb-03 Dec-04 2006 Jun-07 Mar-09 Feb-10 Feb-11 Dec-12
16EW01 16EW02 16EW03 16EW04 16EW05 16EW06 16EW07 16EW08

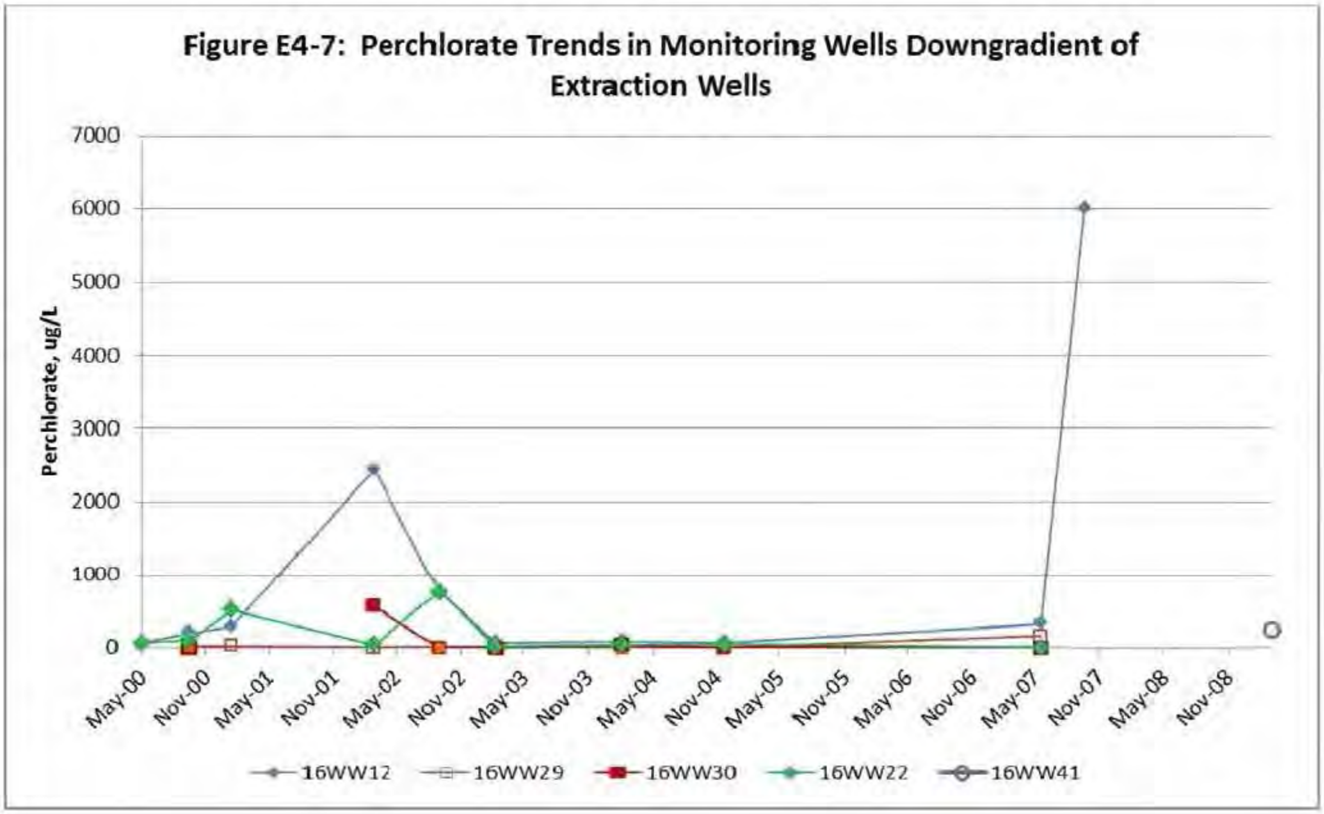


Figure E4-7: Perchlorate Trends in Monitoring Wells Downgradient of Extraction Wells
Perchlorate, ug/L
7000
6000
5000
4000
3000
2000
1000
0
May-00
Nov-00
May-01
Nov-01
May-02
Nov-02
May-03
Nov-03
May-04
Nov-04
May-05
Nov-05
May-06
Nov-06
May-07
Nov-07
May-08
Nov-08
16WW12
16WW29
16WW30
16WW22
16WW41

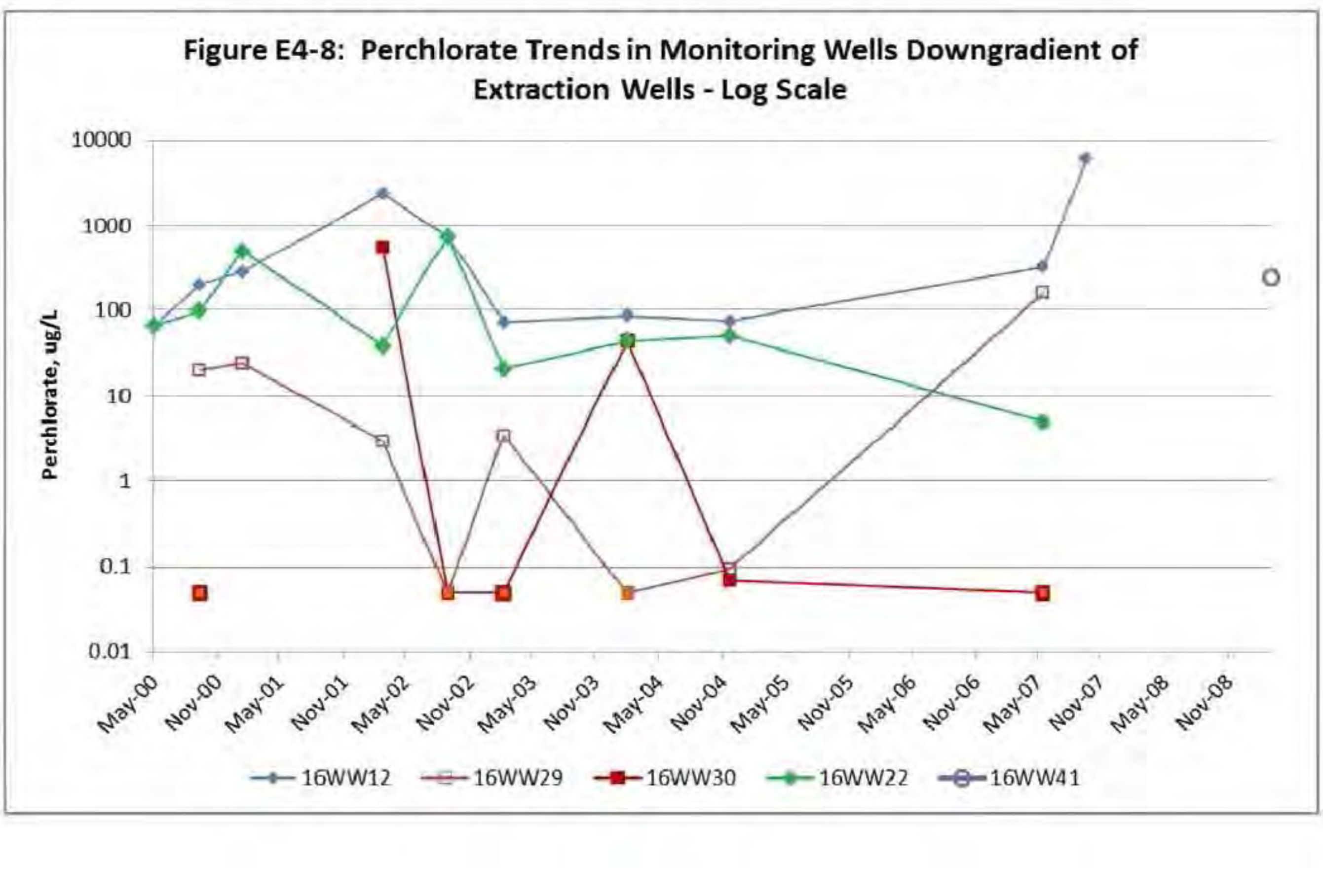


Figure E4-8: Perchlorate Trends in Monitoring Wells Downgradient of Extraction Wells - Log Scale
Perchlorate, ug/L
10000
1000
100
10
1
0.1
0.01
May-00
Nov-00
May-01
Nov-01
May-02
Nov-02
May-03
Nov-03
May-04
Nov-04
May-05
Nov-05
May-06
Nov-06
May-07
Nov-07
May-08
Nov-08
16WW12
16WW29
16WW30
16WW22
16WW41

APPENDIX E5: Five-Year Review Site Inspection Checklist

FIVE-YEAR REVIEW SITE INSPECTION CHECKLIST

Information may be completed by hand and attached to the five-year review report as supporting documentation of site status. "N/A" refers to "not applicable."

I. SITE INFORMATION

Site Name: Longhorn Army Ammunition Plant Site: LHAAP-016 (Old Landfill)	Date of Inspection: Dec. 17, 2012
Location and Region: Karnack, TX; EPA Region 6	**EPA ID: TX6213820529**
Agency, office or company leading the five-year review: AECOM under contract to the U.S. Army	Weather/temperature: Sun, Warm temperatures hi 50's to low 60's °F.

Remedy Includes: (Check all that apply)
☒ Landfill cover/containment
☒ Access controls
☒ Institutional controls
☒ Ground water pump and treatment
NA Surface water collection and treatment
☐ Other –

Attachments: ☐ Inspection team roster attached
Inspection Team Members: David D. Gammans, Gretchen McDonnell, Dave Wacker
☐ Site map attached

II. INTERVIEWS (Check all that apply)

1. O&M Site Manager | **Title** | **Date**
Name, Affiliation: Scott Beesinger | O&M Site Manager | Dec. 20, 2012

Interviewed: ☐ by mail ☒ at office ☐ by phone Phone no. (903)217-9954
Problems, suggestions: ☒ Report attached (Refer to Appendix I)

2. O&M Staff | **Title** | **Date**
Name, Affiliation: Ray Wagner | O&M Staff | Dec. 20, 2012

Interviewed: ☐ by mail ☒ at office ☐ by phone Phone no. (903)679-3448
Problems, suggestions: ☐ Report attached

II. INTERVIEWS (continued)

3. Local regulatory authorities and response agencies (i.e.; State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.). Fill in all that apply.

Agency
Contact ______ ______ ______ ______
Name Title Date Phone no.

Problems, suggestions: ☒ Report attached (Refer to Appendix I)

Agency______
Contact______ ______ ______ ______
Name Title Date Phone no.

Problems, suggestions: ☒ Report attached (Refer to Appendix I)

4. Other interviews (optional) ☒ Report attached (Refer to Appendix I) (Refer to Appendix I)

1.
2.
3.
4.
5.

III. ONSITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. O&M Documents

☒ O&M Manual (see below)	☒ Readily available	☒ Up to date	☐ N/A
☒ As-built drawings	☒ Readily available	☒ Up to date	☐ N/A
☒ Maintenance logs	☒ Readily available	☒ Up to date	☐ N/A

Remarks: 1) Recorded Daily, Reported Weekly

2. Site-Specific Health and Safety Plan ☒ Readily available ☒ Up to date ☐ N/A

☐ Contingency plan/emergency response plan	☒ Readily available	☒ Up to date	☐ N/A

Remarks:

III. ONSITE DOCUMENTS & RECORDS VERIFIED (continued)

3. O&M and OSHA Training Records ☒ Readily available ☒ Up to date ☐ N/A

Remarks: ________________

4. Permits and Service Agreements

☐ Air discharge permit	☐ Readily available	☐ Up to date	☒ N/A
☐ Effluent discharge	☐ Readily available	☐ Up to date	☒ N/A
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	☒ N/A
☐ Other permits	☐ Readily available	☐ Up to date	☒ N/A

Remarks:

5. Gas Generation Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

6. Settlement Monument Records x☐ Readily available ☐ Up to date ☐ N/A

Remarks: Not located

7. Ground Water Monitoring Records ☒ Readily available ☒ Up to date ☐ N/A

Remarks: AECOM electronic database, monthly and quarterly reports

8. Leachate Extraction Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

9. Discharge Compliance Records

☒ Air	☒ Readily available	☐ Up to date	☐ N/A
☒ Water (effluent)	☒ Readily available	☐ Up to date	☐ N/A

Remarks: Monitoring per the 2007 Sampling and Analysis Plan, Groundwater Treatment Plant and Well Fields (Shaw, 2007). Records maintained at GWTP. Quarterly Evaluation Reports maintained in Department of Army, Administrative Record.

10. Daily Access/Security Logs ☒ Readily available ☒ Up to date ☐ N/A

Remarks: Daily Sign In Sheet at Groundwater Treatment Plant. Gated fence around landfill perimeter. Access road to Groundwater Treatment Plant is gated with code key for entry. Warning signs posted at the gate and on perimeter fence. Log maintained for access.

IV. O&M COSTS

1. O&M Organization

☐ State in-house ☐ Contractor for State

☐ PRP in-house ☐ Contractor for PRP

☒ Other (Example: Contractor for U.S. Army Corps of Engineers)

(Please see Section 4.0 of the Five-Year Review Report (2013) for cost information)

2. O&M Cost Records

☐ Readily available ☐ Up to date

☒ Funding mechanism/agreement in place

Original O&M cost estimate See main body text ____ ☐ Breakdown attached

Total annual cost by year for review period, if available

From ________ to____ ______ ☐ Breakdown attached
Date Date Total cost

From __ to____ ______ ☐ Breakdown attached
Date Date Total cost

From ________ to____ ______ ☐ Breakdown attached
Date Date Total cost

From ________ to____ ______ ☐ Breakdown attached
Date Date Total cost

From ________ to___ ______ ☐ Breakdown attached
Date Date Total cost

3. Unanticipated or Unusually High O&M Costs During Review Period

Describe costs and reasons:

1._
2.
3.____
4.____
5.____

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. Fencing damaged ☐ Location shown on map ☐ Gates secure ☐ N/A

Remarks: Restricted landfill area fencing complete around landfill perimeter. Good to excellent condition with no noticeable breeches in barbed wire. Access road gate presently has unrestricted access due to additional path around gate.

B. Other Access Restrictions

1. Signs and other security measures ☐ Location shown on map ☐ N/A

Remarks: Signage on fencing and gate around landfill perimeter. A few signs missing along west edge of landfill.

C. Institutional Controls

1. Implementation and enforcement

Site conditions imply ICs not properly implemented	☐ Yes	☒ No	☐ N/A
Site conditions imply ICs not being fully enforced	☐ Yes	☒ No	☐ N/A

Type of monitoring (e.g., self-reporting, drive by) Self-reporting. Drive by during most work days.

Frequency

Responsible party/agency U.S. Army

Contact

Ms. Rose M. Zeiler (PhD)	Site Manager	NA	(479)635-0110
Name	Title	Date	Phone no.

Reporting is up-to-date	☐ Yes	☐ No	☐ N/A
Reports are verified by the lead agency	☐ Yes	☐ No	☒ N/A
Specific requirements in deed or decision documents have been met	☐ Yes	☐ No	☐ N/A
Violations have been reported	☐ Yes	☐ No	☒ N/A

Other problems or suggestions: LUC plans dated 2007 and 2013 do not include LHAAP 16 ☐ Report attached

2. Adequacy ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A

Remarks: All construction activities at the Base must also be cleared by the environmental group to address any potential exposure issues.

D. General

1. Vandalism/trespassing ☐ Location shown on site map ☐ No vandalism evident

Remarks: Minor vandalism of shed/pump house and trespassing, but none on landfill area.

V.D ACCESS AND INSTITUTIONAL CONTROLS (continued)

2. Land use changes on site ☐ N/A
Remarks: None.

3. Land use changes off site ☐ N/A
Remarks: None, Caddo Lake National Wildlife Refuge

VI. GENERAL SITE CONDITIONS

A. Roads ☒ Applicable ☐ N/A

1. Roads damaged ☐ Location shown on site map ☒ Roads adequate ☐ N/A
Remarks:

B. Other Site Conditions
Remarks: General Landfill Condition is Excellent.

VII. LANDFILL COVERS ☒ Applicable ☐ N/A

A. Landfill Surface

1. Settlement (Low spots) ☐ Location shown on site map ☐ Settlement not evident
Arial extent Depth

Remarks: Few Subsidence Areas Marked with flagging: Central, West 30'X30', Central, North ~40X10' Areas ~ 0.5 ft deep. All areas surveyed for GPS coordinates.

2. Cracks ☐ Location shown on site map ☒ Cracking not evident
Lengths Widths Depths
Remarks:

3. Erosion ☐ Location shown on site map ☐ Erosion not evident
Arial extent Depth
Remarks: Minor washout of surface soil and grasses with sparse vegetation especially near west edge. West areas are ~ 20'X15' and ~50' X 30', East areas are ~15'X30' and ~10'X50', Additional slight erosion areas located north and northeast. Areas surveyed for GPS coordinates.

VII.A LANDFILL COVERS (continued)

4. Holes ☐ Location shown on site map ☐ Holes not evident
Arial extent Depth
Remarks: One small animal burrow noticed in the east – central area, west of the drainage swale.

5. Vegetative Cover ☒ Grass ☐ Cover properly established ☐ No signs of stress

☐ Trees/Shrubs (indicate size and locations on a diagram)
Remarks: No trees/shrubs in fenced landfill. Grasses regularly mowed and appear as natural cover.

6. Alternative Cover (armored rock, concrete, etc.) x☐ N/A
Remarks:

7. Bulges ☐ Location shown on site map ☒ Bulges not evident
Arial extent Depth

Remarks:

8. Wet Areas/Water Damage ☒ Wet areas/water damage not evident
☐ Wet areas ☐ Location shown on site map ☐ Arial extent
☐ Ponding ☐ Location shown on site map ☐ Arial extent
☐ Seeps ☐ Location shown on site map ☐ Arial extent
☐ Soft subgrade ☐ Location shown on site map ☐ Arial extent

Remarks:

9. Slope Instability ☐ Slides ☐ Location shown on site map ☒ No evidence of slope instability

Arial extent

Remarks:

B. Benches ☐ Applicable ☒ N/A

1. Flows Bypass Bench ☐ Location shown on site map ☒ N/A or okay

Remarks:

VII.B LANDFILL COVERS (continued)

2. Bench Breached ☐ Location shown on site map ☒ N/A or okay
Remarks:

3. Bench Overtopped ☐ Location shown on site map ☒ N/A or okay
Remarks:

C. Letdown Channels ☒ Applicable ☐ N/A
(Swale lined with erosion visible, large diameter rip-rap that descends down the fairly steep side slope of the cover, allowing the runoff water to move off of the landfill cover without creating erosion gullies.)

1. Settlement ☐ Location shown on site map ☐ No evidence of settlement
Arial extent Depth
Remarks: As Noted Minor Subsidence Areas in Section A 1 Above.

2. Material Degradation ☐ Location shown on site map ☒ No evidence of degradation
Material type Arial extent
Remarks:

3. Erosion ☐ Location shown on site map ☐ No evidence of erosion
Arial extent Depth
Remarks: As Noted Minor Erosion in Section A 3 Above.

4. Undercutting ☐ Location shown on site map ☒ No evidence of undercutting
Arial extent Depth
Remarks:

5. Obstructions Type ☒ No obstructions
☐ Location shown on site map Arial extent
Size
Remarks:

6. Excessive Vegetative Growth Type
☒ No evidence of excessive growth
☐ Vegetation in channels does not obstruct flow
☐ Location shown on site map Arial extent
Remarks:

VII. LANDFILL COVERS (continued)			
D. Cover Penetrations		☐ Applicable	☒ N/A
1. Gas Vents	☐ Active	☐ Passive	
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs maintenance	☒ N/A
Remarks:			
2. Gas Monitoring Probes			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☒ N/A
Remarks:			
3. Monitoring Wells (within surface area of landfill)			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☒ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☐ N/A
Remarks: Located one of eleven Monitoring Wells in landfill shown on older Site Maps			
4. Leachate Extraction Wells			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☒ N/A
Remarks:			
5. Settlement Monuments	☐ Located	☐ Routinely surveyed	☒ N/A
Remarks:			
E. Gas Collection and Treatment		☐ Applicable	☒ N/A
1. Gas Treatment Facilities			☒ N/A
☐ Flaring	☐ Thermal destruction	☐ Collection for reuse	
☐ Good condition		☐ Needs Maintenance	
Remarks:			
2. Gas Collection Wells, Manifolds, and Piping			☒ N/A
☐ Good condition		☐ Needs Maintenance	
Remarks:			
3. Gas Monitoring Facilities (e.g., gas monitoring of adjacent homes or buildings)			☒ N/A
☐ Good condition		☐ Needs Maintenance	
Remarks:			

VII. LANDFILL COVERS (continued)			
F. Cover Drainage Layer		☐ Applicable	☒ N/A
1. Outlet Pipes Inspected Remarks:		☐ Functioning	☒ N/A
2. Outlet Rock Inspected Remarks:		☐ Functioning	☒ N/A
G. Detention/Sedimentation Ponds		☐ Applicable	☒ N/A
1. Siltation Remarks:	Arial extent Siltation not evident	Depth	☐ N/A
2. Erosion Remarks:	Arial extent Erosion not evident	Depth	
3. Outlet Works Remarks:	☐ Functioning	☐ N/A	
4. Dam Remarks:	☐ Functioning	☐ N/A	
H. Retaining Walls	☐ Applicable	☒ N/A	
1. Deformations Horizontal displacement Rotational displacement Remarks:	☐ Location shown on site map	Vertical displacement	☐ Deformation not evident
2. Degradation Remarks:	☐ Location shown on site map		☐ Degradation not evident

VII. LANDFILL COVERS (continued)		
I. Perimeter Ditches/Off-Site Discharge	☒ Applicable	☐ N/A
1. Siltation Arial extent Remarks:	☐ Location shown on site map Depth	☒ Siltation not evident
2. Vegetative Growth ☒ Vegetation does not impede flow Arial extent Remarks:	☐ Location shown on site map Type	☐ N/A
3. Erosion Arial extent Remarks:	☐ Location shown on site map Depth	☒ Erosion not evident
4. Discharge Structure Remarks:	☐ Functioning	☒ N/A

VIII. VERTICAL BARRIER WALLS	☐ Applicable	☒ N/A
1. Settlement Arial extent Remarks:	☐ Location shown on site map ☐ Depth	☐ Settlement not evident
2. Performance Monitoring ☐ Performance not monitored Frequency Head differential Remarks:	Type of monitoring	☐ Evidence of breaching
IX. GROUNDWATER/SURFACE WATER REMEDIES	☒ Applicable	☐ N/A
A. Groundwater Extraction Wells, Pumps, and Pipelines	☒ Applicable	☐ N/A
1. Pumps, Wellhead Plumbing, and Electrical ☐ Good condition ☐ All required wells located Remarks: Maintenance and optimization being conducted at time of site visit.	☒ Needs maintenance	☐ N/A

IX. GROUNDWATER/SURFACE WATER REMEDIES ☒ Applicable ☐ N/A

2. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances

☐ Good condition ☒ Needs maintenance

Remarks: see IX. 1.

3. Spare Parts and Equipment

☒ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks:.

B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ☒ N/A

1. Collection Structures, Pumps, and Electrical

☐ Good condition ☐ Needs maintenance

Remarks:

2. Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances

☐ Good condition ☐ Needs maintenance

Remarks:

3. Spare Parts and Equipment

☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks:

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply) – CGWTP inspected

☒ Metals removal ☐ Oil/water separation ☐ Bioremediation
☒ Air stripping ☐ Carbon adsorbers
☒ Filters
☒ Additive (e.g., chelation agent, flocculent)
☒ Others
☒ Good condition ☐ Needs maintenance
☒ Sampling ports properly marked and functional
☒ Sampling/maintenance log displayed and up to date
☒ Equipment properly identified
☐ Quantity of ground water treated annually
☐ Quantity of surface water treated annually

Remarks:

IX.C. GROUND WATER/SURFACE WATER REMEDIES (continued)

2. Electrical Enclosures and Panels (Properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs maintenance
Remarks:

3. Tanks, Vaults, Storage Vessels
☐ N/A ☒ Good condition ☒ Proper secondary containment ☐ Needs maintenance
Remarks:

4. Discharge Structure and Appurtenances
☐ N/A ☒ Good condition ☐ Needs maintenance
Remarks:

5. Treatment Building(s)
☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks:

6. Monitoring Wells (Pump and treatment remedy)
☐ Properly secured/locked ☐ Functioning ☒ Routinely sampled ☐ Good condition
☐ All required wells located ☐ Needs maintenance ☐ N/A
Remarks: Site Monitoring Well Maintenance Planned.

D. Monitoring Data

1. Monitoring Data
☒ Is routinely sampled on time x☐ Is of acceptable quality

2. Monitoring Data Suggests
☐ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining (with minor exceptions, see text of Five-Year Review report)

E. Monitored Natural Attenuation ☐ Applicable ☒ N/A

1. Monitoring Wells (Natural attenuation remedy)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ All required wells located ☒ Needs maintenance ☐ N/A
Remarks: MNA will be a component of the final remedy, which was in the design phase at the time of this five year review.

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

The components of the final remedy such as enhanced LUCs, in situ bioremediation, biobarriers and MNA are in the design phase.

In accordance with the IRA (ROD 1995), the cap construction completed in 1999 has been providing protection by minimizing the vertical infiltration of water into the landfill. The cap does not control migration of COCs located in underlying groundwater prior to cap construction or continuing to migrate should a source be present below the water table. Monitoring well 16WW16 (close to the landfill boundary) had a fairly high TCE concentration (18,900 μg/L), March 2009. Select wells need to be monitored to track COC transport that continues to migrate from groundwater underlying the cap. The TCE and perchlorate plumes that have migrated beyond the landfill boundary are controlled by an existing extraction system. This system is providing some hydraulic containment of the most contaminated portion of groundwater in the shallow and intermediate aquifers. The system has been operating at 25% of the design capacity and is currently being optimized. TCE concentrations appear to be increasing at downgradient well 16WW12. Surface water data from HBW-1 (located 100 feet northeast of 16WW12) also indicates potential seepage (TCE and perchlorate) into Harrison Bayou. A final remedy of enhanced insitu bioremediation in the most contaminated area along with a downgradient biobarrier would address this issue and allow a phased shutdown of the extraction system as specified in the ROD. Based on 2003/2004 data, arsenic, manganese, thallium and chromium (inorganic COCs) detected sporadically above cleanup levels in a number of wells also needs continued monitoring.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

The cap is functioning as designed and needs only routine maintenance. The cap is maintained and inspected in accordance with the RCRA requirements. A written O&M Plan for maintenance of the cap for LHAAP-16 is currently not in place, as the maintenance procedures are presently under revision.

The groundwater extraction system has been functioning at a reduced capacity as excessive maintenance of the well pumps, and the associated air compressor caused system downtime (Shaw 2010). The extraction system was temporarily shutdown in August 2012 due to operational issues. The system has recently undergone major repairs and has been operating much more efficiently.

XI. OVERALL OBSERVATIONS (continued)

C. Early Indicators of Potential Remedy Failure

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future.

Analysis of costs is provided in the main body of this report. There were also no indicators of potential failure observed during this five-year review inspection.

D. Opportunities for Optimization

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

1. None. The final remedy is in the design phase.
2.
3.
4.

Individual Site Notes – Field Reconnaissance

Longhorn Army Ammunition Plant, Karnack, TX.

2013 Five Year Review

Site: LHAAP-012 **Date: 12/17/12**

Field Team: Dave Wacker, Gretchen McDonnell, Dave Gammans

Findings:	Remedy:
1. Unlocked Gate:	Needs New Lock, Securing
2. Numerous Subsidence Areas Marked with flagging:	GPS Coordinates Recorded
a. Central ~10'X12'	
b. West Edge three small areas ~10X20' and two combined at ~8'X40'	
c. North End ~40'X40'	
d. Northwest Mower ruts ~10'X30'.	
Most areas ~ 1 to 1.5 ft deep.	Backfill, Tamper, Regrade, Vegetate
3. Minor washout surface soil and grasses on east edge.	Grade, Vegetate
4. East Edge fence line old, former animal burrow.	Check for activity, backfill and grade
5. Monitoring Well Identification, Condition – Out of date	Confirm IDs, repainting, remarking, some locks, hinge repair (see well list)

Site: LHAAP-016 **Date: 12/17/12**

Field Team: Dave Wacker, Gretchen McDonnell, Dave Gammans

Findings:	Remedy:
1. Access Unrestricted @ Gate:	Needs Barbed Wire to limit access around gate
2. Signage Missing Along Fence line	Replace
3. Few, Small Subsidence Areas Marked with flagging	
a. Central, West 30'X30'	
b. Central, North ~40X10'	
Areas ~ 0.5 ft deep.	Backfill, Tamper, Regrade, Vegetate
4. Minor erosion surface soil, sparse vegetation esp.west edge	Grade, Vegetate
a. West 20'X15' and 50'X30'	
b. East 15'X30' and 10'X50'	
c. Northeast, Slight	
d. North, Slight	
5. Animal burrow. East Central near swale	Check for activity, backfill and grade
6. Monitoring Well Identification, Condition	Confirm IDs, repainting, remarking, growth clearing, some pad repairs, some locks, hinge repair (see well list)

Site: LHAAP-018/ 024 **Date: 12/19 and 20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Unlocked Gate	Needs New Lock, Securing
2. Gate Signage Illegible	Replace with new signs
3. Signage Missing Along Fence line	Replace
4. Few areas of Fence Have Excessive Vegetation	Clearing / Maintenance
5. Monitoring Well Identification, Condition – Out of date	Inspection, Confirm IDs, Repainting, Remarking, Locks, Repair or Abandon as needed

Site: Groundwater Treatment Plant (GWTP) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Rust Corrosion on Activated Carbon Vessels	Recondition, Repaint
2. Rust Corrosion on PK200B Tank	Recondition, Repaint
3. Rust Residue Below PK140 Influent Holding Tank Flange	Recondition, Repaint
4. System Optimization	Engineering Review
5. Level Probe Hydrochloric Acid Tank	Needs Engineering Review, Repair

Site: Former Pistol Range (LHAAP-004-R-01) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Daily Access/Security Logs	Review LUC Management Plan and Determine Fish and Wildlife Service and/or US Army Responsibility
2. Missing Signage, Gate Access	Review Plan As Above
3. Former Monitoring Well Abandonment	Research, Confirm, Possible Search

Site: Former Acid Plant (LHAAP-049) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Daily Access/Security Logs	Review LUC Management Plan and Determine Fish and Wildlife Service and/or US Army Responsibility
2. Missing Signage, Access	Review Plan As Above
3. Monitoring Wells Identification, Condition	Research, Confirm IDs, Repainting, Remarking, Growth Clearing, Repair or Abandon as needed

APPENDIX E6: Photographs

AECOM

Photo Log

Longhorn Army Ammunition Plant, Karnack, TX.

2013 Five Year Review

Photo #	Date	Site	Description
101_1021.JPG	12/17/12	LHAAP-016	Animal burrow in Landfill 16, East Central Near Swale
101_1022.JPG	12/17/12	"	Landfill Central Area Looking West
101_1023.JPG	12/17/12	"	Landfill Central Area Looking East
101_1024.JPG	12/17/12	"	Landfill Surface (poor quality photo)
101_1025.JPG	12/17/12	"	Landfill East Side Minor Erosion, Sparse Vegetation Area
101_1026.JPG	12/17/12	"	Landfill East Side Minor Erosion, Sparse Vegetation Area (Mower Tracks)
101_1027.JPG	12/17/12	"	Landfill Drainage Swale Looking Northwest
101_1028.JPG	12/17/12	"	Drainage Swale, Large Cobblestone Surface
101_1029.JPG	12/17/12	"	Landfill West, Central Slight Subsidence Area
101_1030.JPG	12/17/12	"	Landfill North, Bare - Slight Washout Area
101_1031.JPG	12/17/12	LHAAP-016	Landfill Northeast Slight Washout Area, Mower Tracks
101_1032.JPG	12/17/12	"	Landfill Area Looking North
101_1033.JPG	12/17/12	"	Landfill Central Area Looking Northeast
101_1034.JPG	12/17/12	"	Landfill Panoramic View (3 photos combined)

Weather: sun, slight wind, temps hi 50's to low 60's °F.

Field Team: David Gammans, Dave Wacker, Gretchen McDonnell

Camera Details: Kodak EasyShare M5350, 16 MP

Photograph Files Location: c:\Users\GammansD\Longhorn 5yr\Travel\field work forms\Completed Site Forms\12-17-2012

Additional Comments:


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012


12/17/2012

APPENDIX F: LHAAP 18/24 Supporting Documents

APPENDIX F1: Documents Reviewed

Documents Reviewed for LHAAP-18/24

Army Environmental Hygiene Agency (AEHA), 1976. *Final Report Water Quality Special Study No. 24-0586-77, U.S. Army Environmental Hygiene Agency, Aberdeen Proving Ground,* Vol 1 of 1, 000001 – 000032. August

AEHA, 1978. *Final Report Air and Water Pollution Survey, Horacek, Smith, Painter & Spitz, Incorporated,* Vol 1 of 1, 000033 – 000077. April.

AEHA, 1980. *Final Report - AEHA Land Disposal Study No. 38-26-0104-81-82, AEHA Aberdeen Proving Ground*, AR 1980 Vol 1 of 1, 000078 - 000196, 1980LandDispStdy-vol. 01.pdf. February.

AWD Technologies, Inc., 1994. *Physical Surveying and Other Field Data, Early Interim Action at Burning Ground No.3, LHAAP-18 & LHAAP-24 Burning Ground/ Washout Pond & Unlined Evaporation Pond, Longhorn Army Ammunition Plant, Marshall, TX,* 1994 Vol 2 of 13 L. 007897 – 007985, 1994-vol. 02 (of 13).pdf. February.

Becher, Kent, 2012. U.S. Department of the Interior, U.S. Geological Survey, *Quality Assurance Split Sampling at Selected Sites, Longhorn Army Ammunition Plant Longhorn*, AR 2012 Vol 1 of 1 A, 00113584 – 00113593, 2012 USGS SplitSmplng ppt from 2012 Vol1.pdf. January.

Becher, Kent; Braun, Christopher; and Pearson, Daniel, 2012. U.S. Department of the Interior, U.S. Geological Survey, *Evaluation of Interim Remedial Action at Longhorn Army Ammunition Plant site 18/24, Karnack, Texas*. February.

Burrows, Don, 1998. Radian International LLC, *Proof of Performance Test Results, Groundwater Treatment Plant, Interim Remedial Action Burning Ground No.3, Longhorn Army Ammunition Plant, Karnack, Texas*, AR 1998 Vol 3 of 4 B, 023345-023388, 1998 Proof of Performance.pdf. June.

Complete Environmental Service, Inc., 2002. *Final Report- Five-Year Review Report- for Sites 18 & 24 (Burning Ground 3), Site 16 (Old Landfill), and Site 12 (Sanitary Landfill) at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, AR 2002 Vol 3 of 4 A, 029146-029297, 2002_1st-5yr_reviewComplEnvService.pdf. August.

Dow Environmental, Inc. (Dow), 1995. *Interim Remedial Action Burning Ground No. 3 and Unlined Evaporation Pond, Pilot Study Report - Phase II, Longhorn Army Ammunition Plant, Karnack, Texas*, AR 2009 Vol 3 of 13 G, 00073624 - 00073693, 1995IRA PilotStudyPHII from 2009 Vol 3 of 13.pdf. March.

Dow, 1995. *Final General Work Plan Interim Remedial Action, Burning Ground No. 3, Longhorn Army Ammunition Plant, Karnack, Texas*, Volume 1, AR 1995 Vol 11 of 10 K, 016353-016708, 1995-IRAWork Plan vol. 11 (of 10).pdf. December.

Environmental Protection Systems, Inc., 1983. *Final Analysis Report - Contamination Analysis Report for Environmental Contamination Survey of the Longhorn Army Ammunition Plant, Marshall, Texas*, Vol 1 of 1 A, 000197 – 0005051984, ContamAnalRpt +ClosureRpt.pdf. March.

Environmental Protection Systems, Inc., 1984. *Longhorn Army Ammunition Plant Contamination Survey*, 2011 Vol 1 of 16 A, 00099012 – 00099233, 1984 Contam Survey-frm2011Vol1.pdf. June.

Jacobs Engineering Group Inc (Jacobs), 2001, *Final Remedial Investigation Report for the Group 2 Sites Remedial Investigation (Sites 12,17,18/24, 29 and 32) at the Longhorn Army Ammunition Plant Karnack Texas,* 2001 Vol 1 of 2 A, 025526 – 025828, 2001-Jacobs RI vol 01.pdf. April.

Jacobs, 2001. *Final Report - Remedial Investigation Report - Volume 2: Appendix I - Figures, for Group 2 Sites Remedial Investigation Report, Sites 12,17, 18/24,29, and 32 at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, 2001 Vol 1 of 2 B. 025829 – 025880. April.

Jacobs, 2001, *Final Report - Remedial Investigation Report - Volume 3: Appendices II-IV, for Group 2 Sites Remedial Investigation Report, Sites 12,17, 18/24,29, and 32 at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, 2001 Vol 1 of 2 C. 025881 – 026577. April.

Jacobs, 2002. *Final Report - Baseline Human Health and Screening Ecological Risk Assessment: - Volume 1: Report, for Group 2 Sites, Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake, at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, AR 2002 Vol 3 of 4 B, 029298 – 029954, 2002-vol. 03 (of 04) JacobsBaselineHlth.pdf. August.

Kindle, Stone and Associates, Inc, 1984. *Closure of Unlined Evaporation Pond*, Vol 1 of 1 B, 000506 – 000880, 1984ContamAnalRpt+ClosureRpt.pdf. July.

Kindle, Stone and Associates, Inc, 1985. Scope of Work - *Specifications For Closure Of Unlined Evaporation Pond*, Project No. DACA 87-84-C-0039Vol 1 of 1, B, 000882 – 001178, 1985ClosureStats.pdf. August.

Shaw Environmental Inc. (Shaw), 2004. *Final Workplan- Installation-Wide Background Study for the Longhorn Army Ammunition Plant (LHMP), Karnack, Texas*, AR 2004 Vol 1 of 7, 031408-031752. January.

Shaw, 2004. *Final Workplan -Groundwater Data Gaps Investigation, Groups 2 and 4, for the Longhorn Army Ammunition Plant (LHMP), Karnack, Texas*, AR 2004 Vol 1 of 7, 031820-032072. February.

Shaw, 2007. *Evaluation of Perimeter Well Data for Use as Groundwater Background, Shaw Environmental, Inc.*, 2007 Vol 5 of 25 C. 00045756 - 00046051. June.

Shaw, 2007. *Sampling and Analysis Plan Groundwater Treatment Plant and Well Fields, Revision 1*, AR 2007 Vol 8 of 25 I, 00048199 - 00048283, 2007SAP-GWTP Vol 8 of 25.pdf. July.

Shaw, 2007. *Pilot Study Implementation Plan, Groundwater Treatment Plant and Well Fields,* AR 2007 Vol 9 of 25, A, 00048895 - 00048969, 2007 Pilot study GWTP-well fields.pdf. September.

Shaw, 2007. *Quarterly Evaluation Report, 3rd Quarter (July - September) 2007 Groundwater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, TX,* AR unknown, Quarterly Eval Rpt_3rdQtr_Jul-Sep 2007.pdf. November.

Shaw, 2007. *Final Installation-Wide Baseline Ecological Risk Assessment, Volume I,* Longhorn Army Ammunition Plant, Karnack, TX, AR 2007 Vol 10 of 25 A, 00049542 - 00050415, 2007 Final-Instln-Baseline-EcoVol10of25.pdf. November.

Shaw, 2007. *Final Installation-Wide Baseline Ecological Risk Assessment, Volume II, Steps 4 through 8 Report and Appendices L through P, Longhorn Army Ammunition Plant, Karnack, TX,* AR 2007 Vol 21 of 25 B, 00059408 - 00060025, 2007 Final-Instln-Baseline-EcoIIVol 21 of 25.pdf. November.

Shaw, 2008. *Final Five-Year Review, Second Five-Year Review Report for LHAAP-12, LHAAP-16 and LHAAP-18/24, Longhorn Army Ammunition Plant, Karnack, Texas,* AR 2008 Vol 9 of 9 E, 00070660 - 00070845, Sept 2008 five year review with Comnts+APPS.pdf. September.

Shaw, 2010. *Draft Final Feasibility Study LHAAP-18/24 Burning Ground No.3 and Unlined Evaporation Pond, Longhorn Army Ammunition Plant, Karnack, Texas,* 05 10 DRAFT FINAL Feasibility Study LHAAP 18-24.pdf. May.

Shaw, 2012. *Draft Quarterly Evaluation Report, 2nd Quarter (April - June) 2012 Groundwater Treatment Plant, Longhorn Army Ammunition Plant, Karnack, TX,* AR unknown, Quarterly Evaluation Report 2nd Qtr 2012.pdf. August.

Texas Commission on Environmental Quality, 2010. Approval Letter *Final Explanation of Significant Differences, Burning Ground 3 and Unlined Evaporation Pond (Designated as LHAAP-18/24) Interim Remedial Action Record of Decision Dated May 1995,* AR 2010 Volume 8 of 19, B, 00088920 – 00088936, LHAAP18-24ExplSigDiff2010 Vo8 of 19.pdf. February.

Texas Water Commission,1988. *Final Report - RCRA Facility Assessment (RFA),* Vol 2 of 2 B, 001252 - 001909. April.

U.S. Army, 1991. *Final Agreement- Federal Facility Agreement Under CERCLA Section 120, Longhorn Army Ammunition Plant, Marshall, Texas,* AR 1991 Vol 1 of D, 004332-004400, 1991Federal Facility Agreement.pdf. September.

U.S. Army, 2011. *Installation Action Plan-- Longhorn Army Ammunition Plant, Karnack, Texas,* AR 2011 Volume 2 of 16, J, 00100117 – 00100178, June13-2011InstalnActionPlan.pdf. June.

U.S. Army Corps of Engineers (USACE), 1989. *Final Report- Phase I Groundwater Quality Assessment Active Burning Ground and Unlined Evaporation Pond* Volume 3 - (Appendices A Through K), Vol 2 of 5 C, 002089 – 002569. February.

USACE, 1989, F*inal Report - Phase I RCRA Facility Investigation (RFI) Active Burning Ground and Unlined Evaporation Pond Volume 1* – Text, and Volume 2 Sheet Drawings , Volume 4 - Appendixes L through BB, AR 1989 Vol 1 of 5 A, Vol 3 of 5 D, 001910-002056, B, 002057 – 002088, 002570 – 003041, 1989RCRA Inv Logs2060-2063to2074-2079.pdf, 1989RCRA Inv Logs2624-2676+2734-2749vol. 03.pdf. July.

USACE, 1989. *Final Analytical Data-Phase II Field Data RCRA Facility Investigation (RFI)*, Vol 5 of 5 H, 003508 – 004034, (vol4 was QA/QC) 1989PhII logsMW16-23+C4Avol. 05.pdf. September.

USACE, 1992. *Final Workplan - Phase I Remedial Investigation / Feasibility Study (RI / FS) Work Plan*, Volume 1 – General, , Vol 2 of 4 V, 004668 – 005119, 1992RIFSWPp4826-4766MWlocnsXSs-vol2.pdf. June.

USACE, 1993. *Final Analytical Data - Data Summary Report Of Investigation Results From 1976 Through 1992 For Burning Ground 3 & The Unlined Evaporation Pond*, 1993AnalDataLogsMW1-23+C1-C10+others-vol2.pdf. May.

USACE, 1994. *Final Workplan - Phase II Pilot Study For Interim Remedial Action (IRA) For Burning Ground 3 & The Unlined Evaporation Pond*. January.

USACE, 1995. *Record of Decision For Early Interim Remedial Action At Burning Ground No.3*, Longhorn Army Ammunition Plant, Karnack, Texas, AR 1995 Volume 2 of 11,N, 012681 – 012751, LHAAP18+24ROD1995.pdf. May.

USACE, 2003. *Action Plan, for the Longhorn Army Ammunition Plant (LHAAP}, Karnack, Texas*, AR 2003 Volume 1 of 1, 031143-031202, March2003InstalnActionPlan.pdf. March.

USACE, 2010. *Final Feasibility Study, LHAAP-17, Burning Ground No. 2/Flashing Area, Group 2, Longhorn Army Ammunition Plant, Karnack, Texas*, 2010 Vol 9 and 10 of 19 A. 00089088 – 00090092, 00090093 – 00091096, 17FS_2010 Vol9of19.pdf. April.

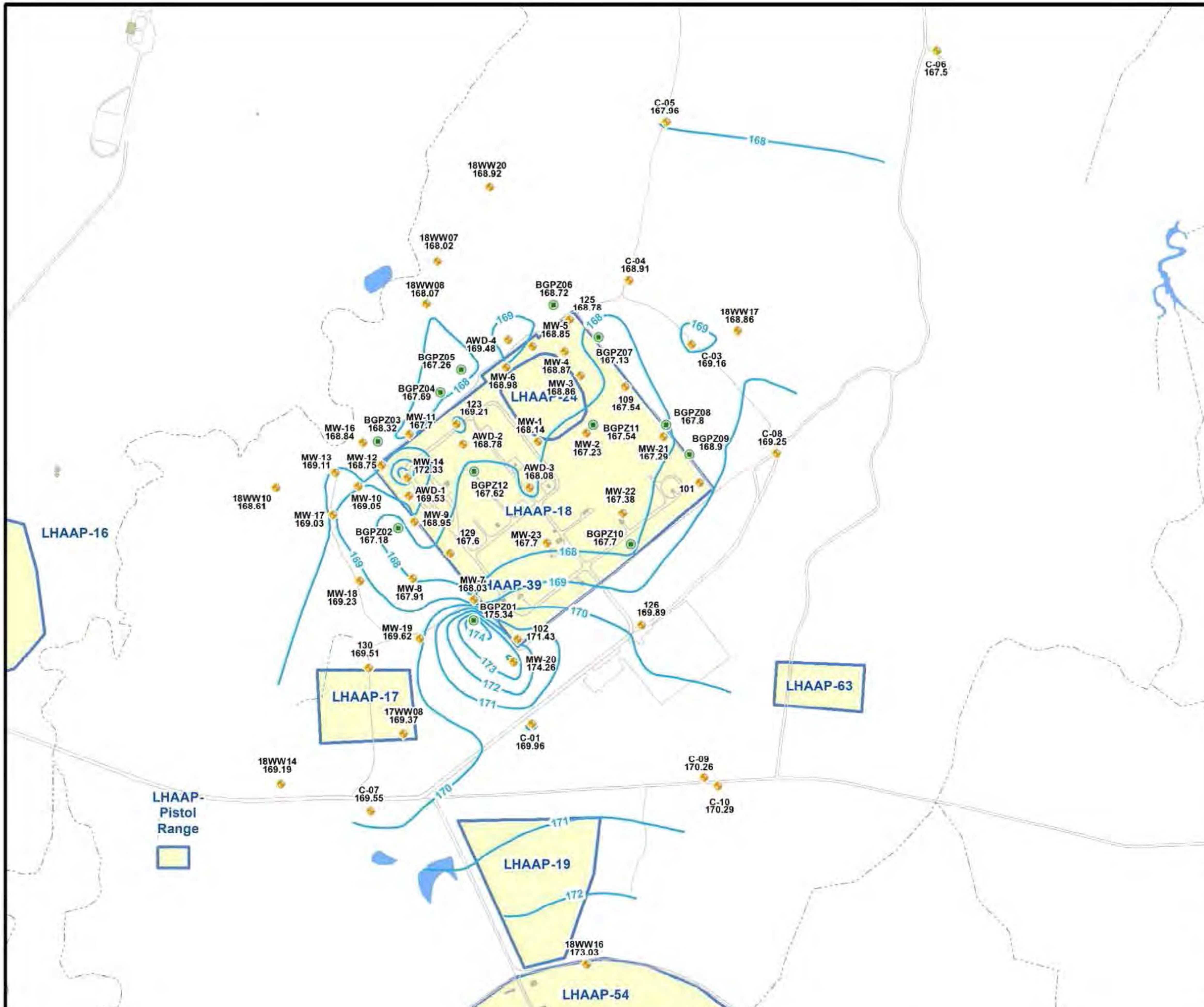
USACE, 2010, *Final Explanation of Significant Differences, Burning Ground 3 and Unlined Evaporation Pond (Designated as LHAAP-18/24) Interim Remedial Action Record of Decision Dated May 1995, Longhorn Army Ammunition Plant, Karnack, Texas*, AR 2010 Volume 8 of 19, B, 00088920 - 00088936, LHAAP18-24ExplSigDiff2010 Vo8 of 19.pdf. August.

U.S. Environmental Protection Agency (USEPA), 1999. Letter- *Early Interim Remedial Action at Burning Ground No. 3 and Landfills 12 and 16- Remedial Action Completion, EPA Region 6 William K. Honker, Chief*, AR 1999 Volume 1 of 1, Z, 024580-024581, LHAAP18-24ExplSigDiff2010 Vo8 of 19.pdf. August.

USEPA, 2001. Office of Emergency and Remedial Response (5204G), *Comprehensive Five-Year Review Guidance*, EPA 540-R-01-007, OSWER No. 9355.7-03B-P. June.

Weston, Inc., 1993. Final Workplan - *Remedial Investigation I Feasibility Study (RIIFS) Final Work Plan Addendum*. September.

APPENDIX F2: Groundwater Elevation Maps



Legend

- Shallow Monitoring Well
- Piezometer Location
- Groundwater Elevation Contour
- Streams
- Roads
- Former Buildings or Concrete Slab
- Site Boundary

0 250 500 1,000 Feet

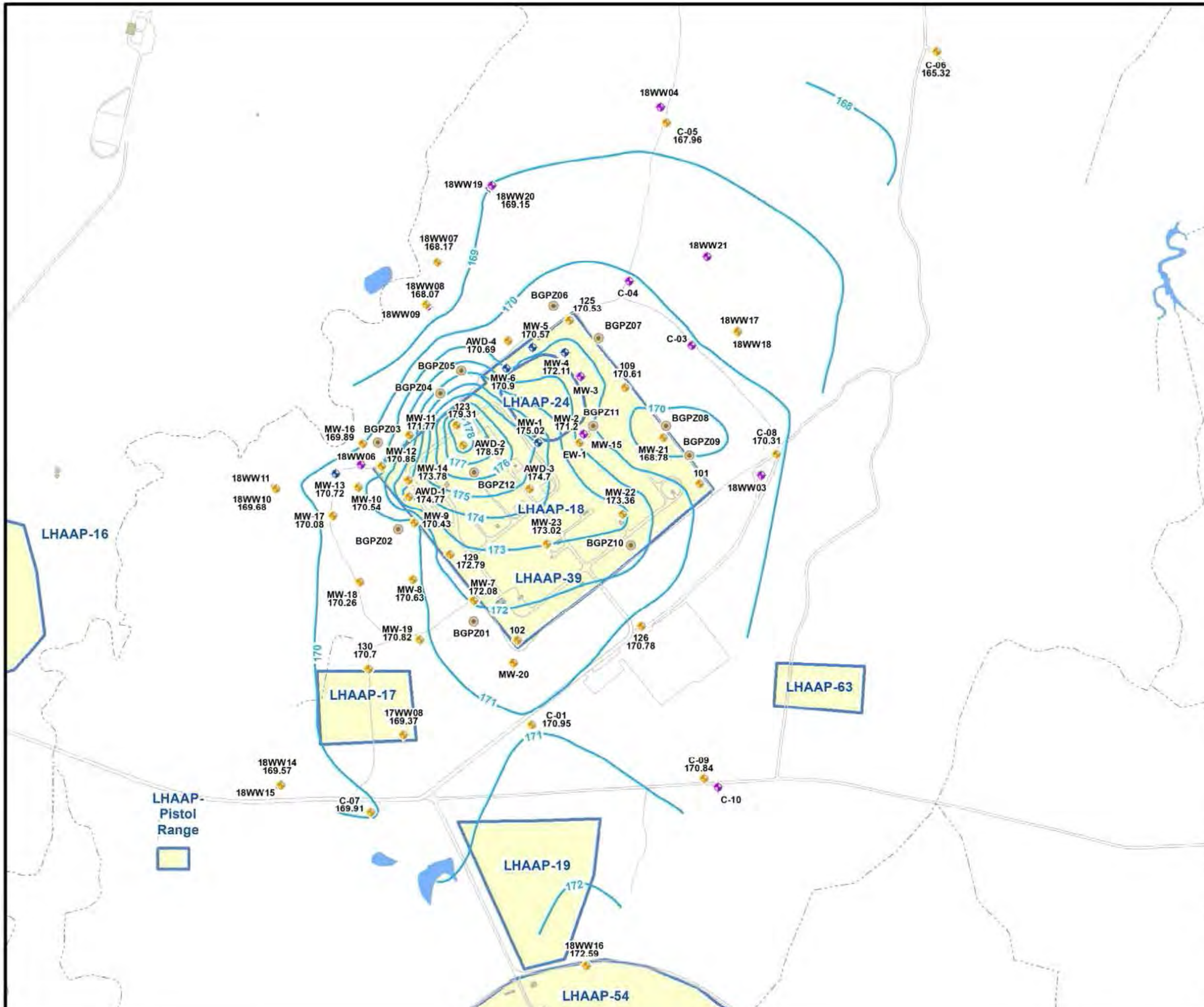
AECOM

112 Pecan Street
Suite 400
San Antonio, Texas 78205

Shallow Groundwater Potentiometric Surface Elevation Contours - LHAAP-18/24
May 2006

Longhorn Army Ammunition Plant
Karnack, Texas

PROJECT NO.	DRAWN BY:	DATE:	
60256135	TEG	2/5/2013	**Figure F2-1**



Legend

- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Piezometer Location
- Groundwater Elevation Contour
- Streams
- Roads
- Former Buildings or Concrete Slab
- Site Boundary

0 250 500 1,000 Feet

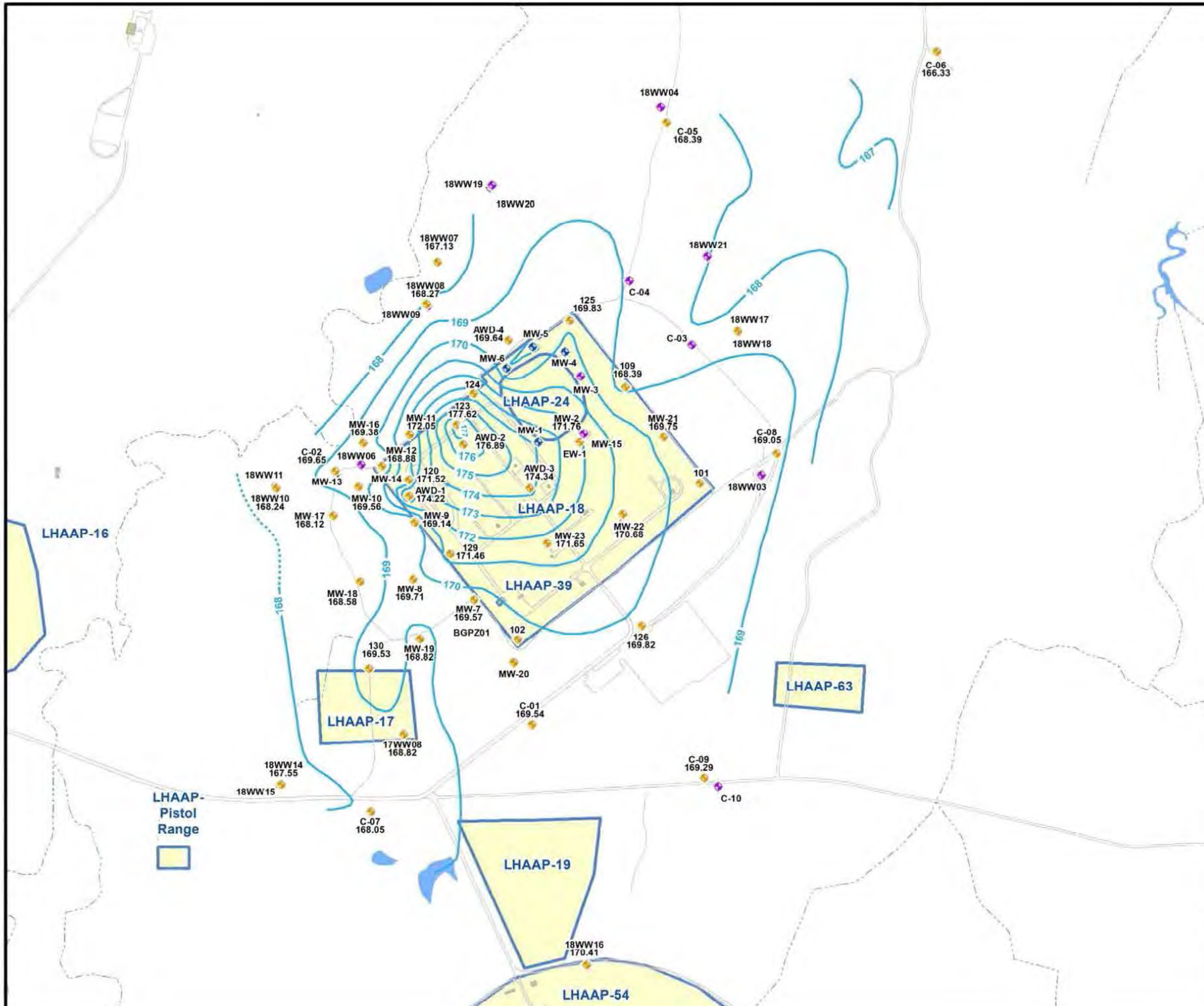
N W E S

AECOM

112 Pecan Street
Suite 400
San Antonio, Texas 78205

Shallow Groundwater Potentiometric Surface Elevation Contours - LHAAP-18/24
November 2009
Longhorn Army Ammunition Plant
Karnack, Texas

PROJECT NO.	DRAWN BY:	DATE:	
60256135	TEG	2/5/2013	**Figure F2-2**



Legend

- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Groundwater Elevation Contour (Dashed Where Inferred)
- Streams
- Roads
- Former Buildings or Concrete Slab
- Site Boundary

0 250 500 1,000 Feet

N E S W

AECOM

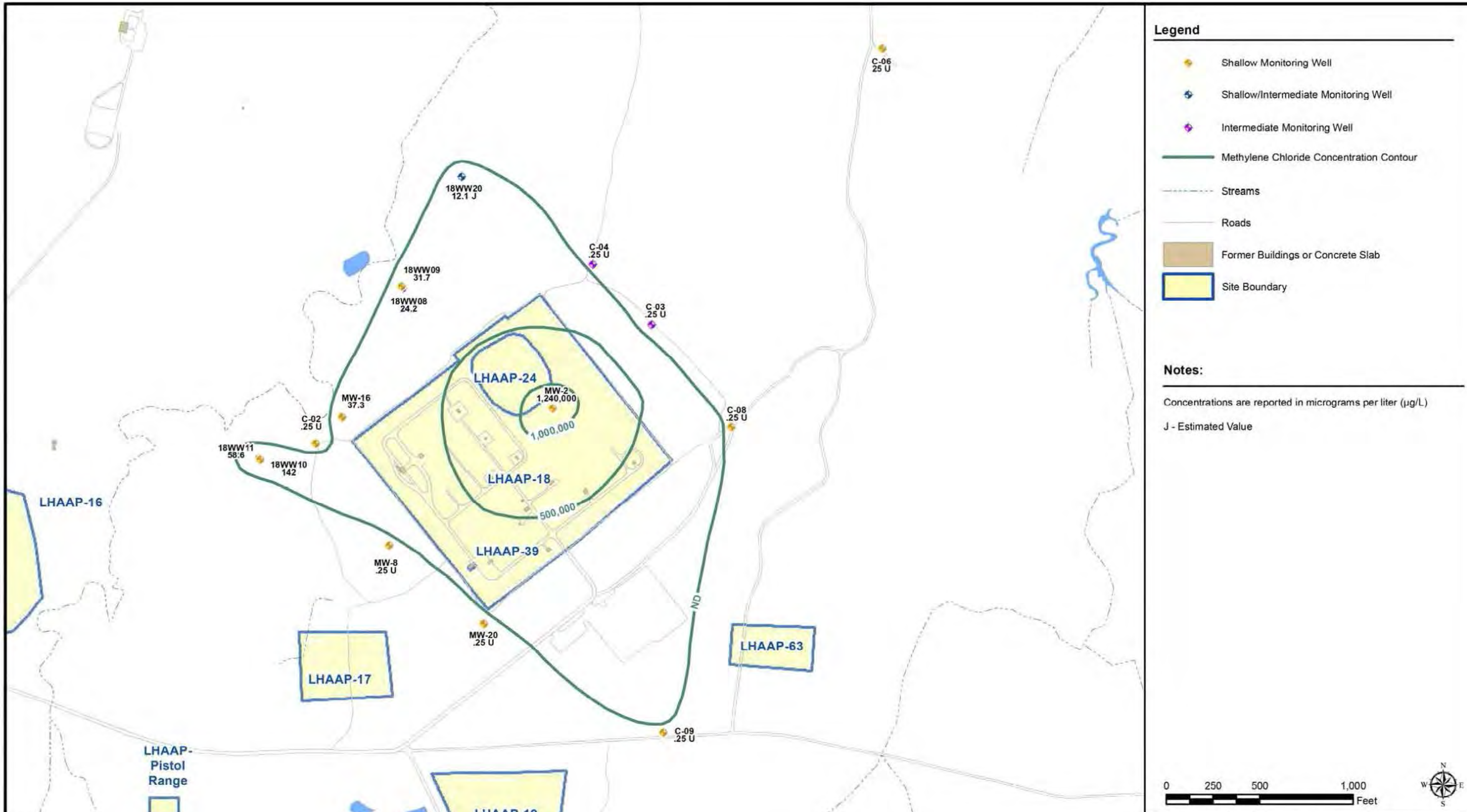
112 Pecan Street
Suite 400
San Antonio, Texas 78205

Shallow Groundwater Potentiometric Surface Elevation Contours - LHAAP-18/24 June 2012

Longhorn Army Ammunition Plant
Karnack, Texas

PROJECT NO:	DRAWN BY:	DATE:	
60256135	TEG	2/5/2013	**Figure F2-3**

APPENDIX F3: Groundwater/Soil Concentration Maps

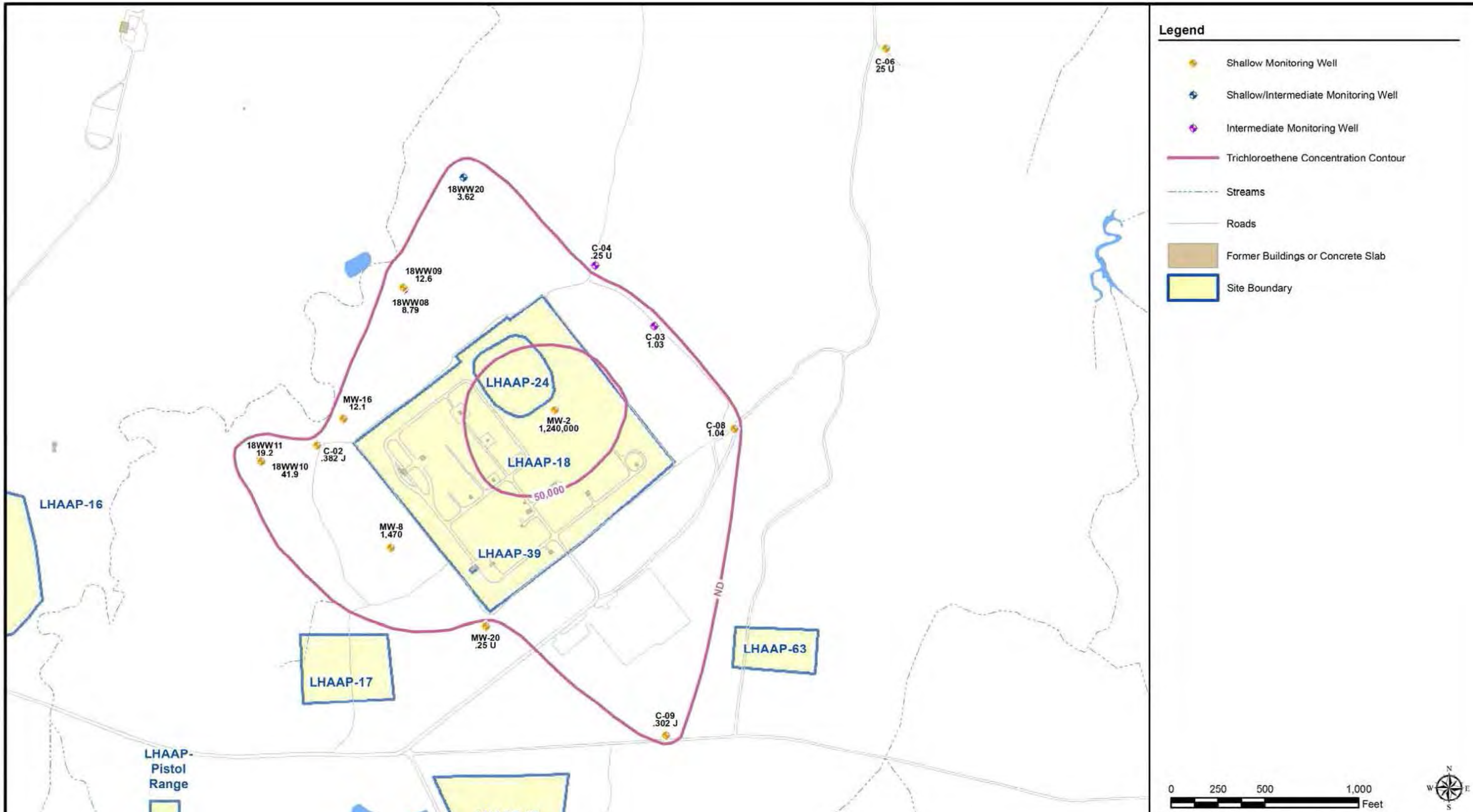


AECOM

112 Pecan Street
Suite 400
San Antonio, Texas 78205

Groundwater Concentration Map
Methlyene Chloride - LHAAP-18/24
September 2007
Longhorn Army Ammunition Plant
Karnack, Texas

PROJECT NO	DRAWN BY:	DATE:	
60256135	TEG	2/15/2013	**Figure F3-1**

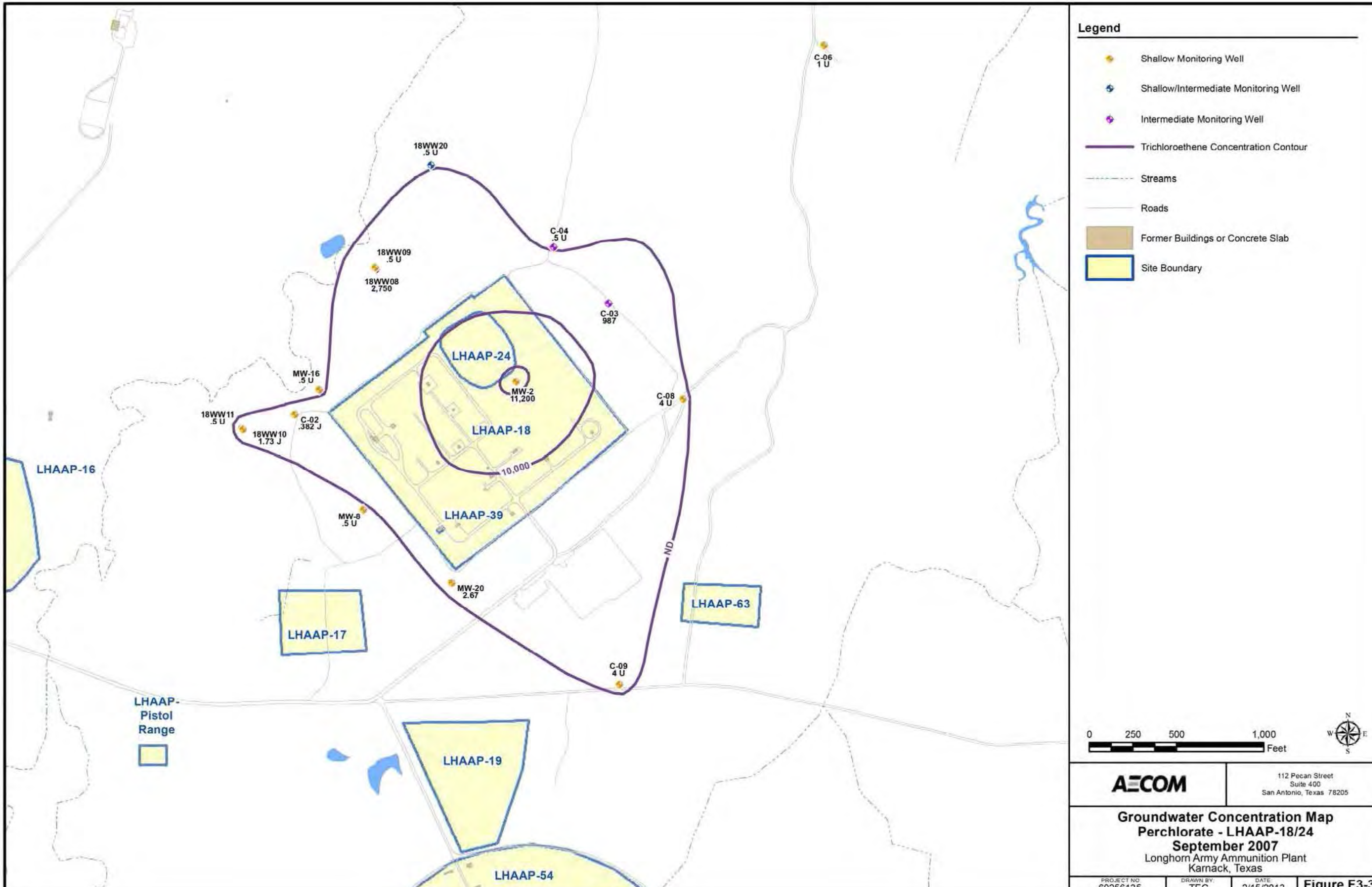


AECOM

112 Pecan Street
Suite 400
San Antonio, Texas 78205

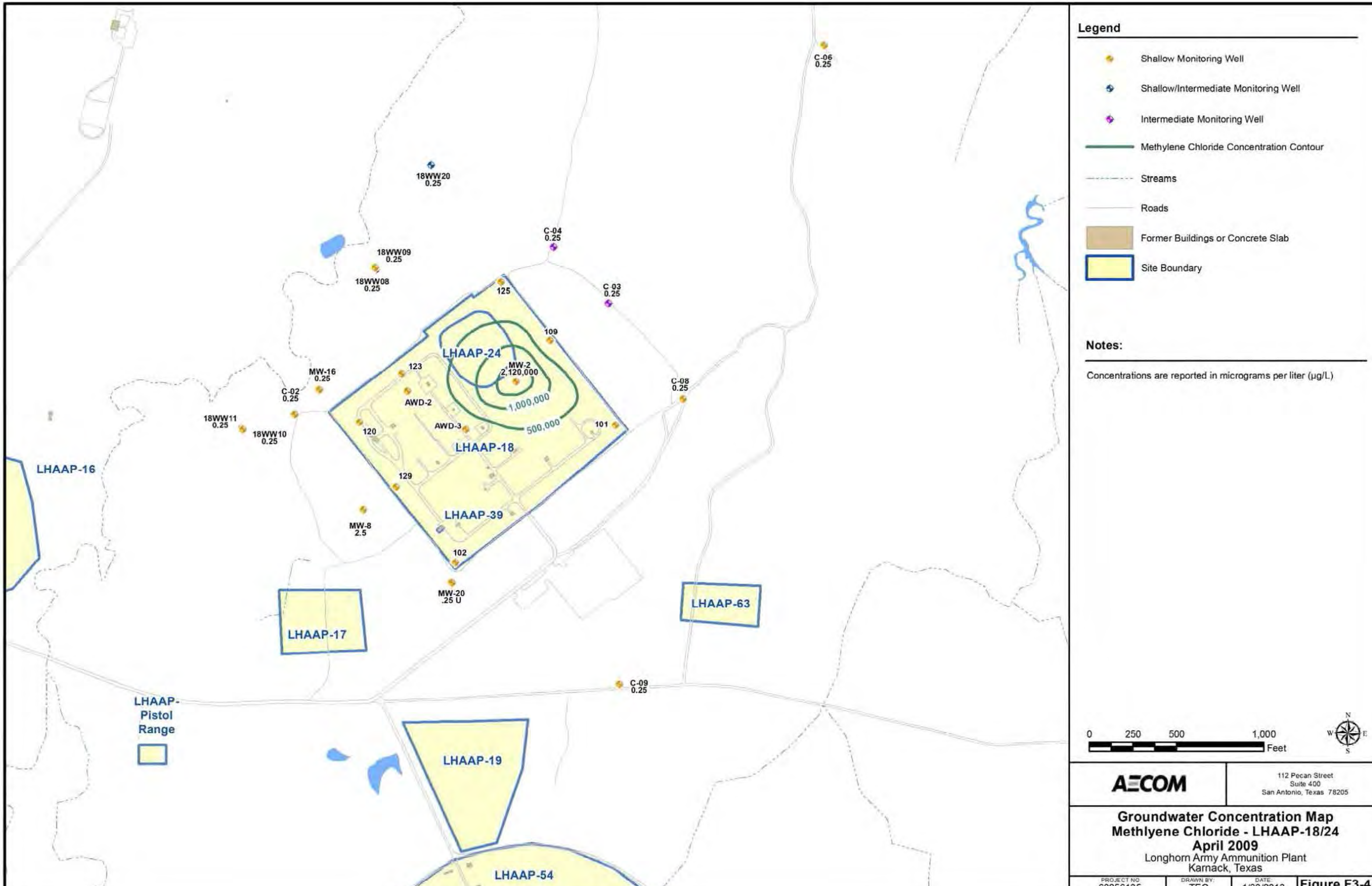
Groundwater Concentration Map
Trichloroethene - LHAAP-18/24
September 2007
Longhorn Army Ammunition Plant
Karnack, Texas

PROJECT NO:	DRAWN BY:	DATE:	
60256135	TEG	2/15/2013	**Figure F3-2**

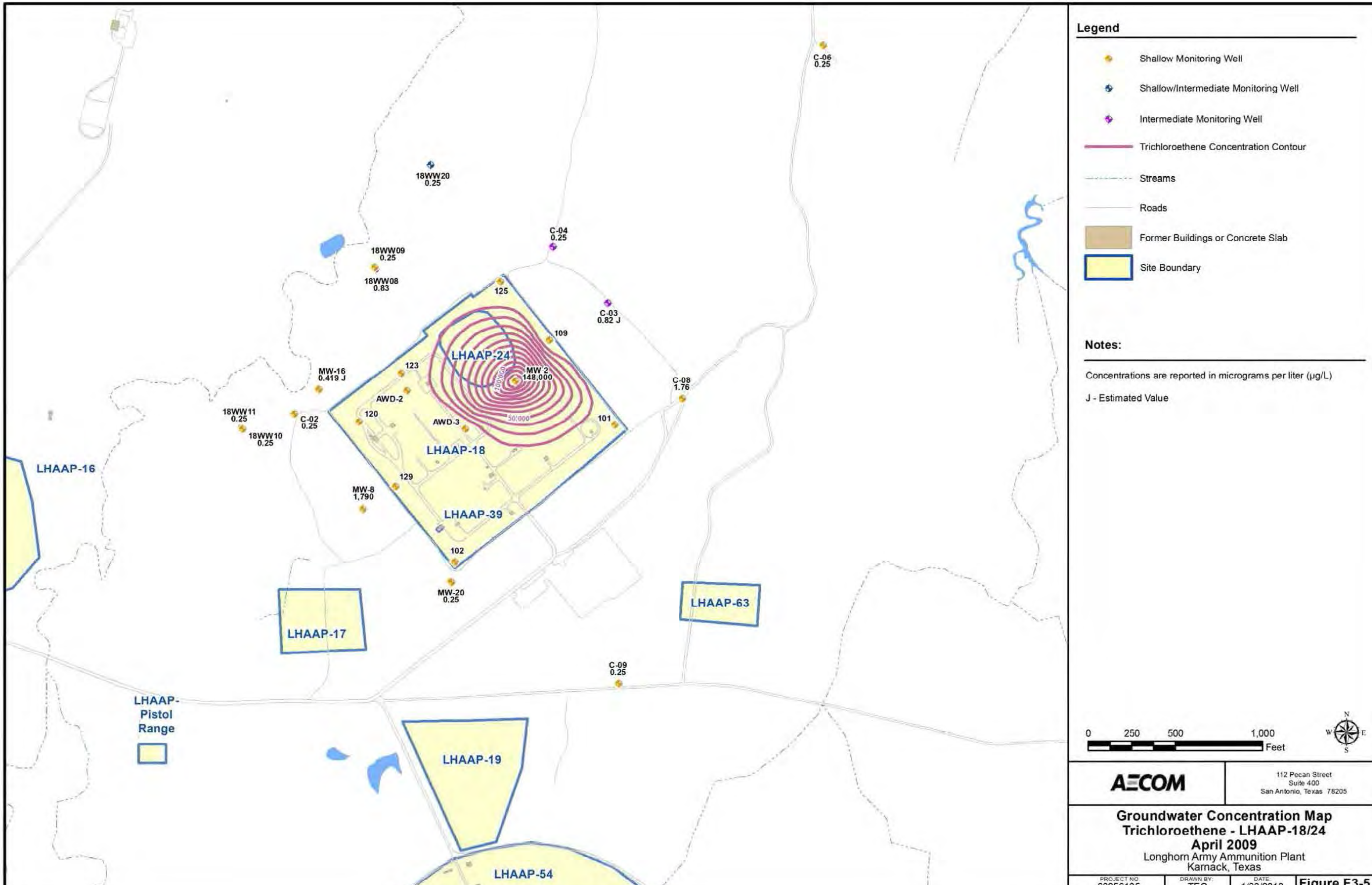


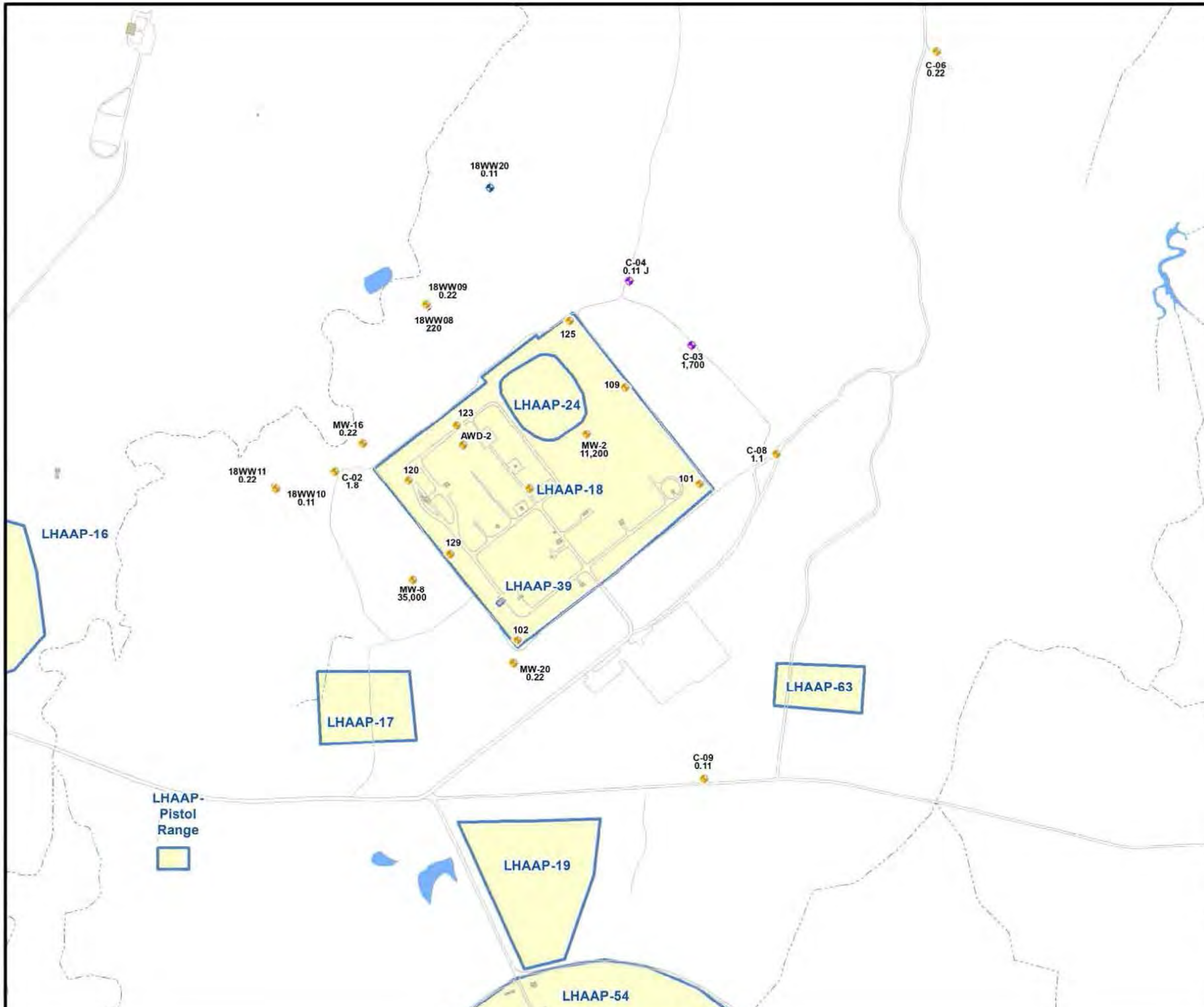
Groundwater Concentration Map
Perchlorate - LHAAP-18/24
September 2007
Longhorn Army Ammunition Plant
Karnack, Texas

Figure F3-3



Legend
Shallow Monitoring Well
Shallow/Intermediate Monitoring Well
Intermediate Monitoring Well
Methylene Chloride Concentration Contour
Streams
Roads
Former Buildings or Concrete Slab
Site Boundary
Notes:
Concentrations are reported in micrograms per liter (µg/L)
0 250 500 1,000 Feet
C-06 0.25
18WW20 0.25
C-04 0.25
18WW09 0.25
18WW08 0.25
125
C 03 0.25
109
LHAAP-24
MW-2 2,120,000
1,000,000
500,000
123
MW-16 0.25
C-02 0.25
AWD-2
AWD-3
C-08 0.25
18WW11 0.25
18WW10 0.25
120
101
LHAAP-18
LHAAP-16
129
LHAAP-39
MW-8 2.5
102
MW-20 .25 U
LHAAP-63
LHAAP-17
C-09 0.25
LHAAP-Pistol Range
LHAAP-19
LHAAP-54
AECOM
112 Pecan Street
Suite 400
San Antonio, Texas 78205
Groundwater Concentration Map
Methlyene Chloride - LHAAP-18/24
April 2009
Longhorn Army Ammunition Plant
Karnack, Texas
PROJECT NO 60256135
DRAWN BY: TEG
DATE: 1/30/2013
Figure F3-4


C-06
0.25
18WW20
0.25
C-04
0.25
18WW09
0.25
18WW08
0.83
125
C-03
0.82 J
109
LHAAP-24
MW-2
148,000
100,000
50,000
123
MW-16
0.419 J
AWD-2
C-08
1.76
18WW11
0.25
C-02
0.25
120
AWD-3
101
18WW10
0.25
LHAAP-18
LHAAP-16
129
MW-8
1,790
LHAAP-39
102
MW-20
0.25
LHAAP-63
LHAAP-17
C-09
0.25
LHAAP-
Pistol
Range
LHAAP-19
LHAAP-54
Legend
Shallow Monitoring Well
Shallow/Intermediate Monitoring Well
Intermediate Monitoring Well
Trichloroethene Concentration Contour
Streams
Roads
Former Buildings or Concrete Slab
Site Boundary
Notes:
Concentrations are reported in micrograms per liter (µg/L)
J - Estimated Value
0
250
500
1,000
Feet
N
W
E
S
AECOM
112 Pecan Street
Suite 400
San Antonio, Texas 78205
Groundwater Concentration Map
Trichloroethene - LHAAP-18/24
April 2009
Longhorn Army Ammunition Plant
Karnack, Texas
PROJECT NO.
60256135
DRAWN BY:
TEG
DATE:
1/30/2013
Figure F3-5



Legend

- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Streams
- Roads
- Former Buildings or Concrete Slab
- Site Boundary

Notes:

Concentrations are reported in micrograms per liter (µg/L)

J - Estimated Value

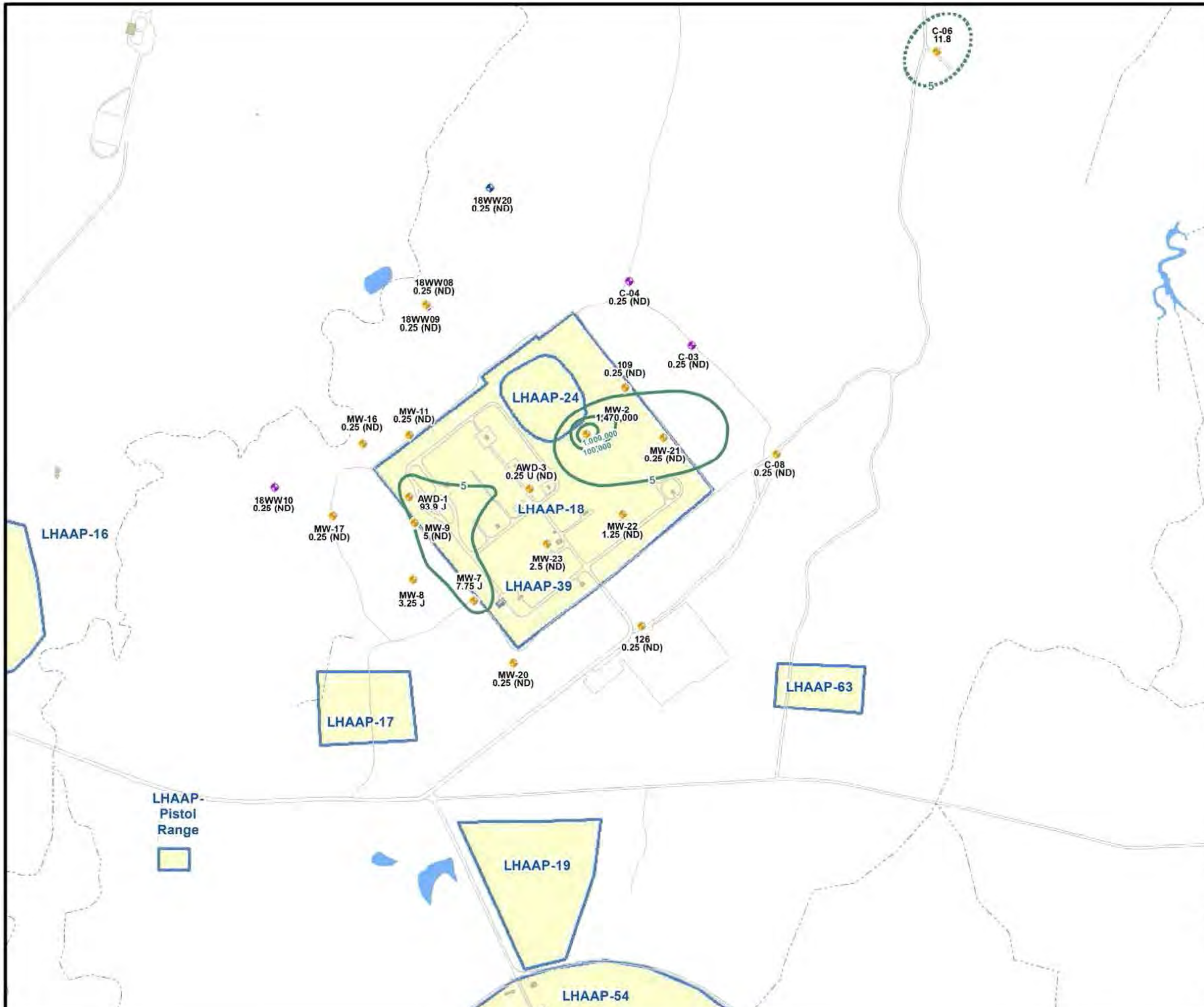
0 250 500 1,000 Feet

AECOM

112 Pecan Street
Suite 400
San Antonio, Texas 78205

Groundwater Concentration Map
Perchlorate - LHAAP-18/24
April 2009
Longhorn Army Ammunition Plant
Karnack, Texas

PROJECT NO	DRAWN BY:	DATE:	
60256135	TEG	1/30/2013	**Figure F3-6**



Legend

- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Methylene Chloride Concentration Contour (Dashed Where Inferred)
- Streams
- Roads
- Former Buildings or Concrete Slab
- Site Boundary

Notes:

Concentrations are reported in micrograms per liter (µg/L)

J - Estimated Value
ND - Non Detect

0 250 500 1,000
Feet

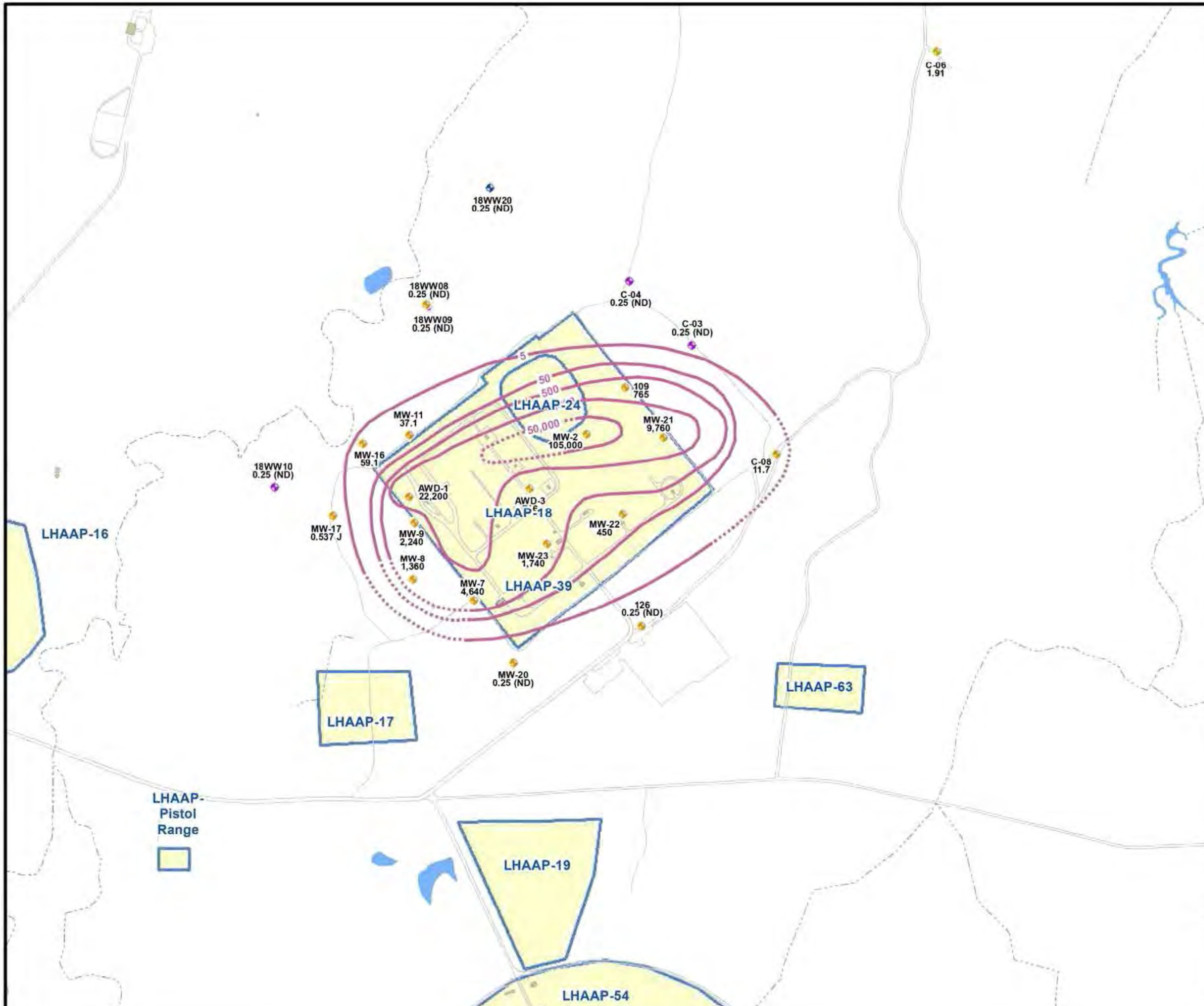
N W E S

AECOM

112 Pecan Street
Suite 400
San Antonio, Texas 78205

Groundwater Concentration Map
Methlyene Chloride - LHAAP-18/24
March 2012
Longhorn Army Ammunition Plant
Karnack, Texas

PROJECT NO.	DRAWN BY:	DATE:	
60256135	TEG	2/15/2013	**Figure F3-7**



Legend

- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Trichloroethene Concentration Contour (Dashed Where Inferred)
- Streams
- Roads
- Former Buildings or Concrete Slab
- Site Boundary

Notes:

Concentrations are reported in micrograms per liter (µg/L)

J - Estimated Value
ND - Non Detect

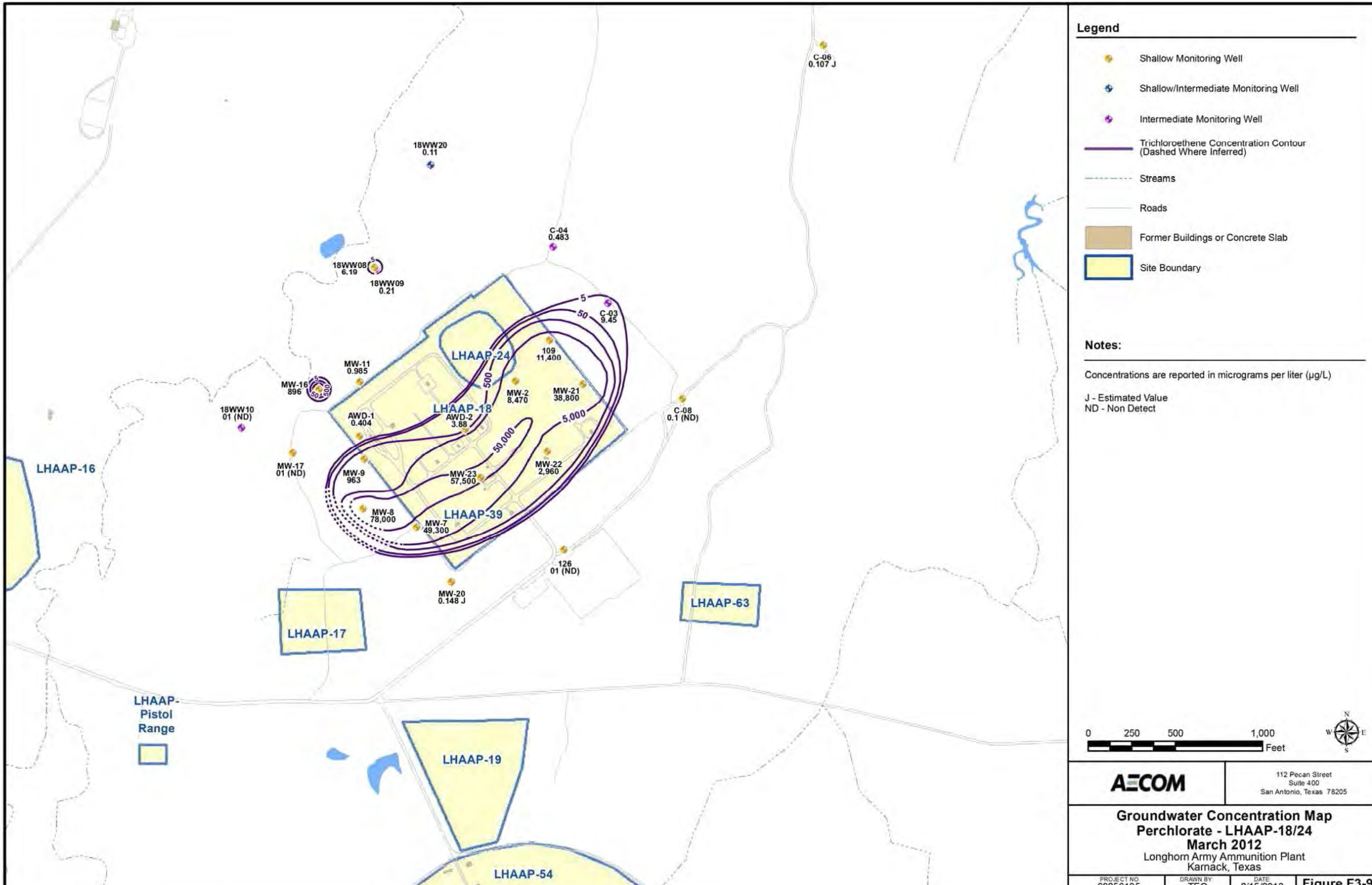
0 250 500 1,000 Feet

AECOM

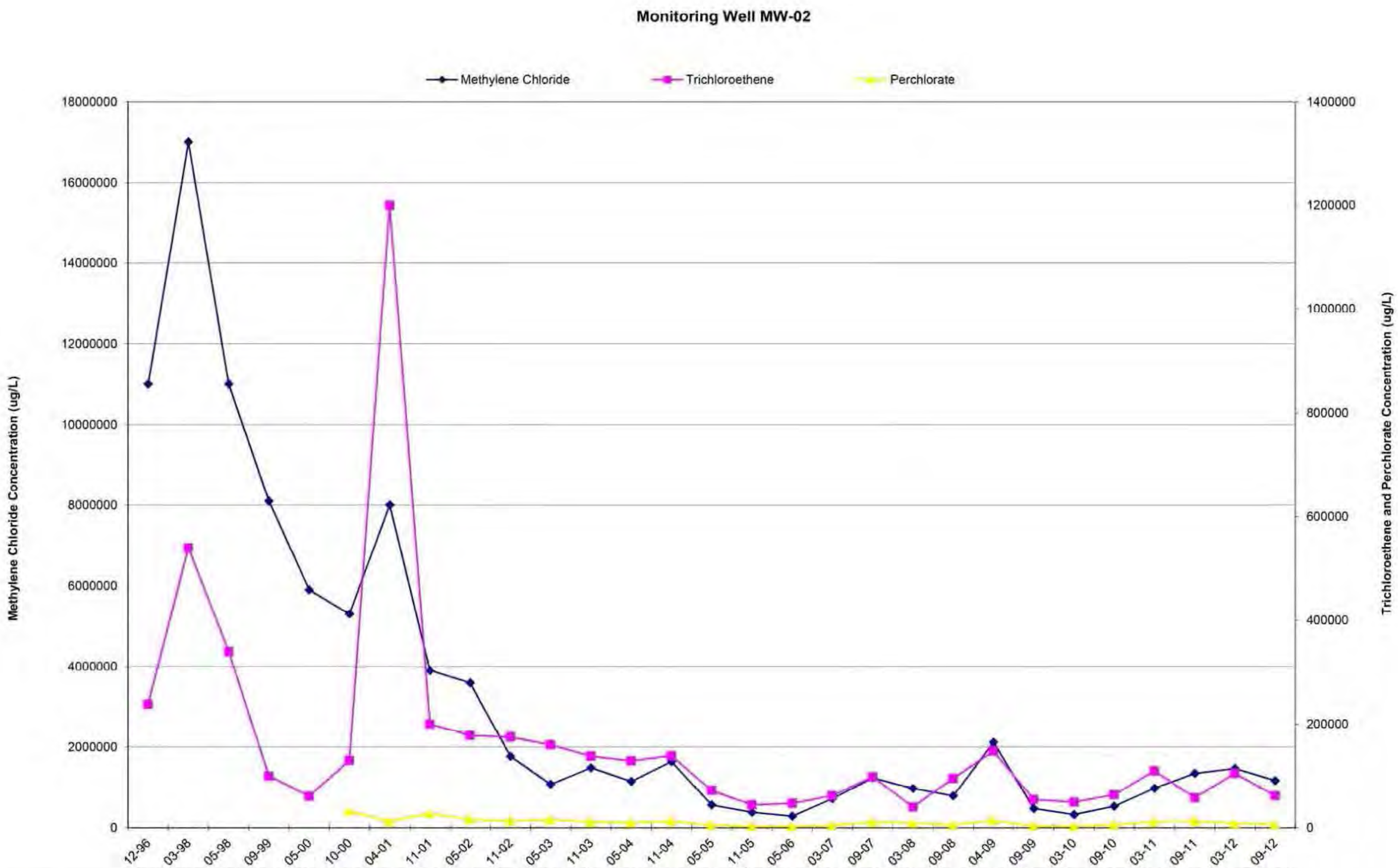
112 Pecan Street
Suite 400
San Antonio, Texas 78205

Groundwater Concentration Map
Trichloroethene - LHAAP-18/24
March 2012
Longhorn Army Ammunition Plant
Karnack, Texas

PROJECT NO.	DRAWN BY:	DATE:	
60256135	TEG	2/15/2013	**Figure F3-8**


Legend
Shallow Monitoring Well
Shallow/Intermediate Monitoring Well
Intermediate Monitoring Well
Trichloroethene Concentration Contour (Dashed Where Inferred)
Streams
Roads
Former Buildings or Concrete Slab
Site Boundary
Notes:
Concentrations are reported in micrograms per liter (µg/L)
J - Estimated Value
ND - Non Detect
0 250 500 1,000
Feet
AECOM
112 Pecan Street
Suite 400
San Antonio, Texas 78205
Groundwater Concentration Map
Perchlorate - LHAAP-18/24
March 2012
Longhorn Army Ammunition Plant
Karnack, Texas
PROJECT NO.
60256135
DRAWN BY:
TEG
DATE:
2/15/2013
Figure F3-9
C-06
0.107 J
18WW20
0.11
C-04
0.483
18WW08
6.19
18WW09
0.21
C-03
9.45
109
11,400
MW-11
0.985
MW-16
896
MW-2
8,470
MW-21
38,800
C-08
0.1 (ND)
18WW10
01 (ND)
AWD-1
0.404
AWD-2
3.88
MW-17
01 (ND)
MW-9
963
MW-23
57,500
MW-22
2,960
MW-8
78,000
MW-7
49,300
126
01 (ND)
MW-20
0.148 J
5
50
500
5,000
50,000
LHAAP-24
LHAAP-18
LHAAP-39
LHAAP-16
LHAAP-17
LHAAP-63
LHAAP-Pistol Range
LHAAP-19
LHAAP-54

APPENDIX F4: Groundwater Time Trend Analysis



	12-96	03-98	05-98	09-99	05-00	10-00	04-01	11-01	05-02	11-02	05-03	11-03	05-04	11-04
Methylene Chloride	1.1E+07	1.7E+07	1.1E+07	8100000	5900000	5300000	8000000	3900000	3590000	1770000	1080000	1490000	1150000	1640000
Trichloroethene	239000	540000	340000	100000	61000	130000	1200000	200000	178000	175000	160000	138000	129000	139000
Perchlorate						32200	12400	27500	15900	13500	15500	11500	9900	12900

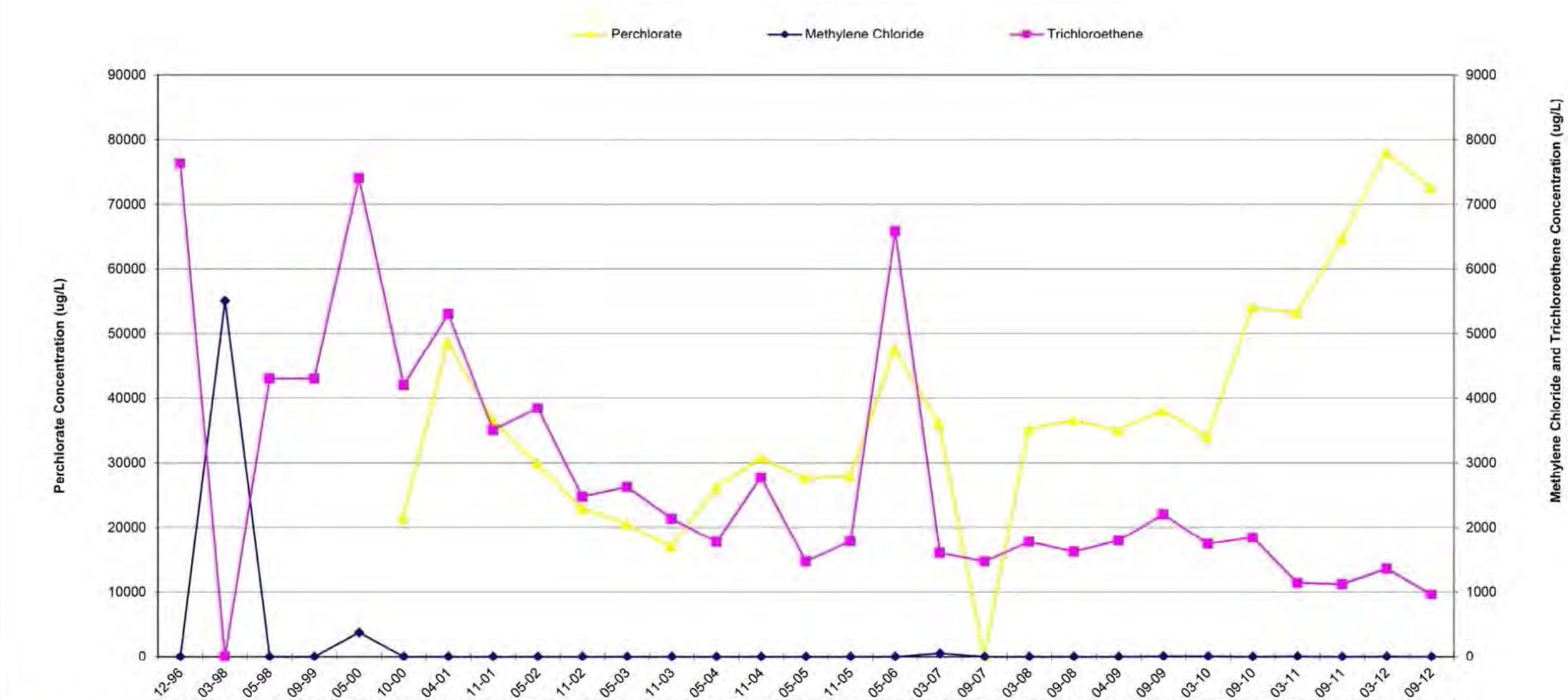
	05-05	11-05	05-06	03-07	09-07	03-08	09-08	04-09	09-09	03-10	09-10	03-11	09-11	03-12	09-12
Methylene Chloride	564000	384000	287000	720000	1240000	974000	790000	2120000	478000	327000	533000	979000	1350000	1470000	1170000
Trichloroethene	71700	44100	47000	62000	98700	40000	95100	148000	54500	49400	63800	110000	57800	105000	61500
Perchlorate	5550	2860	3130	4900	11200	9180	5660	14000	4000	3100	5700	11900	13100	8470	6940

Sample Date

AECOM

Figure F4-1
Time Trend Analysis at MW-2
LHAAP-18/24
Longhorn Army Ammunition Plant, Karnack, Texas

Monitoring Well MW-08



	12-96	03-98	05-98	09-99	05-00	10-00	04-01	11-01	05-02	11-02	05-03	11-03	05-04	11-04	05-05
Perchlorate						21400	48600	36600	29900	22900	20500	17000	26000	30800	27500
Methylene Chloride	0	5500	0	0	370	0	0	0	0	0	0	0	0	0	0
Trichloroethene	7630	0	4300	4300	7400	4200	5300	3,500	3840	2470	2620	2130	1770	2770	1470

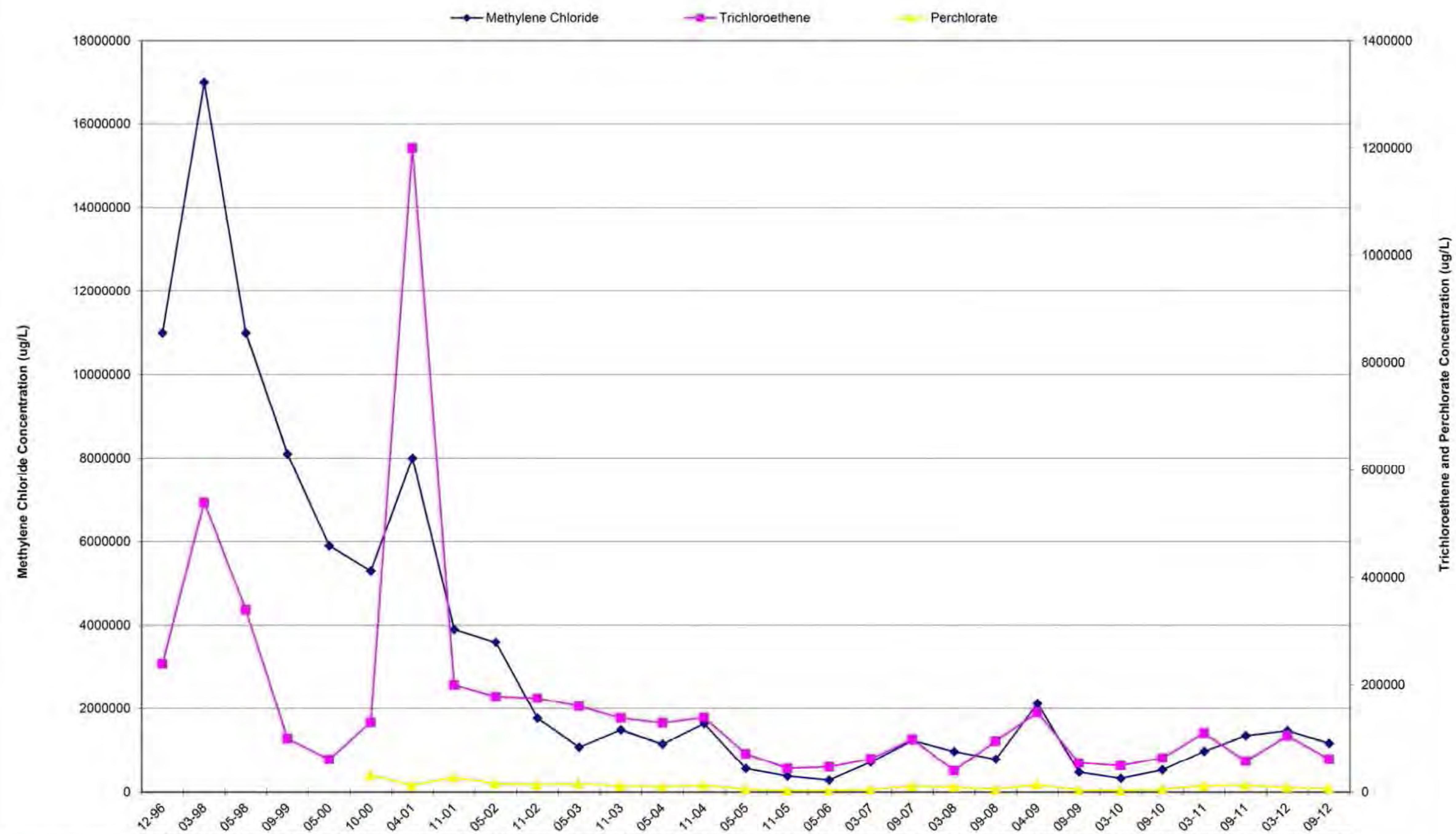
	11-05	05-06	03-07	09-07	03-08	09-08	04-09	09-09	03-10	09-10	03-11	09-11	03-12	09-12
Perchlorate	27900	47500	36000	0	35200	36500	35000	38000	34000	54000	53200	64500	78000	72500
Methylene Chloride	0	0	50	0	0	0	0	6.07	6.27	0	4.11	0	3.25	0
Trichloroethene	1780	6570	1600	1470	1770	1620	1790	2200	1740	1840	1140	1120	1360	959

Sample Date

AECOM

Figure F4-2
Time Trend Analysis at MW-8
LHAAP-18/24
Longhorn Army Ammunition Plant, Karnack, Texas

Monitoring Well MW-02



	12-96	03-98	05-98	09-99	05-00	10-00	04-01	11-01	05-02	11-02	05-03	11-03	05-04	11-04
Methylene Chloride	1.1E+07	1.7E+07	1.1E+07	8100000	5900000	5300000	8000000	3900000	3590000	1770000	1080000	1490000	1150000	1640000
Trichloroethene	239000	540000	340000	100000	61000	130000	1200000	200000	178000	175000	160000	138000	129000	139000
Perchlorate						32200	12400	27500	15900	13500	15500	11500	9900	12900

	05-05	11-05	05-06	03-07	09-07	03-08	09-08	04-09	09-09	03-10	09-10	03-11	09-11	03-12	09-12
Methylene Chloride	564000	384000	287000	720000	1240000	974000	790000	2120000	478000	327000	533000	979000	1350000	1470000	1170000
Trichloroethene	71700	44100	47000	62000	98700	40000	95100	148000	54500	49400	63800	110000	57800	105000	61500
Perchlorate	5550	2860	3130	4900	11200	9180	5660	14000	4000	3100	5700	11900	13100	8470	6940

Sample Date

AECOM

Figure F4-3
Time Trend Analysis at 18WW08
LHAAP-18/24
Longhorn Army Ammunition Plant, Karnack, Texas

APPENDIX F5: Five-Year Review Site Inspection Checklist

FIVE-YEAR REVIEW SITE INSPECTION CHECKLIST

Information may be completed by hand and attached to the five-year review report as supporting documentation of site status. "N/A" refers to "not applicable."

I. SITE INFORMATION	
Site Name: Longhorn Army Ammunition Plant Site: LHAAP-018 / 024 (Former Burning Ground / Unlined Evaporation Pond)	Date of Inspection: Dec. 19 and 20, 2012
Location and Region: Karnack, TX; EPA Region 6	**EPA ID: TX6213820529**
Agency, office or company leading the five-year review: AECOM under contract to the U.S. Army	Weather/temperature: 12/19/12 Overcast, moderate wind, temps low to hi 50's °F, 12/20/12 sun, slight wind, 50's °F.
Remedy Includes: (Check all that apply) ☐ Landfill cover/containment ☒ Access controls ☒ Institutional controls ☒ Ground water pump and treatment NA Surface water collection and treatment ☒ Other –	
Attachments: ☐ Inspection team roster attached Inspection Team Members: David D. Gammans, Scott Beesinger	☐ Site map attached

II. INTERVIEWS (Check all that apply)		
1. O&M Site Manager	**Title**	**Date**
Name, Affiliation: Scott Beesinger	O&M Site Manager	Dec. 20, 2012
Interviewed: ☐ by mail ☒ at office ☐ by phone		Phone no. (903)217-9954
Problems, suggestions: ☒ Report attached (Refer to Appendix I)		
2. O&M Staff	**Title**	**Date**
Name, Affiliation: Ray Wagner	O&M Staff	Dec. 20, 2012
Interviewed: ☐ by mail ☒ at office ☐ by phone		Phone no. (903)679-3448
Problems, suggestions: ☐ Report attached		

II. INTERVIEWS (continued)

3. Local regulatory authorities and response agencies (i.e.; State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.). Fill in all that apply.

Agency
Contact ______ ______ ______ ______
Name Title Date Phone no.

Problems, suggestions: ☒ Report attached __(Refer to Appendix I)______

Agency______________________
Contact______ ______ ______ ______
Name Title Date Phone no.

Problems, suggestions: ☒ Report attached See Interview Record (Refer to Appendix I)

4. Other interviews (optional) ☒ Report attached to Five-Year Review Report (Refer to Appendix I)

1.
2.
3.
4.
5.

III. ONSITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. O&M Documents

☒ O&M Manual (see below)	☒ Readily available	☒ Up to date	☐ N/A
☒ As-built drawings	☒ Readily available	☒ Up to date	☐ N/A
☒ Maintenance logs	☒ Readily available	☒ Up to date	☐ N/A

Remarks: 1) Daily Recording. Records available on-site at Groundwater Treatment Plant (GWTP).
2) Procedures presently under revision.

2. Site-Specific Health and Safety Plan	☒ Readily available	☒ Up to date	☐ N/A
☒ Contingency plan/emergency response plan	☒ Readily available	☒ Up to date	☐ N/A

Remarks: Plans kept at GWTP.

III. ONSITE DOCUMENTS & RECORDS VERIFIED (continued)

3. O&M and OSHA Training Records ☒ Readily available ☒ Up to date ☐ N/A

Remarks: ________________

4. Permits and Service Agreements

☐ Air discharge permit	☐ Readily available	☐ Up to date	☒ N/A
☐ Effluent discharge	☐ Readily available	☐ Up to date	☒ N/A
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	☒ N/A
☒ Other permits	☒ Readily available	☒ Up to date	☐ N/A

Remarks:
Catalytic oxidation unit under standard exemption for air emissions, documentation on-site. Air monitoring per the 2007 Sampling and Analysis Plan, Groundwater Treatment Plant and Well Fields (Shaw, 2007).

5. Gas Generation Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

6. Settlement Monument Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

7. Ground Water Monitoring Records ☒ Readily available ☐ Up to date ☐ N/A

Remarks: Records maintained in Department of Army Administrative Record, Aecom electronic database, monthly and quarterly reports.

8. Leachate Extraction Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

9. Discharge Compliance Records

☒ Air	☒ Readily available	☐ Up to date	☐ N/A
☒ Water (effluent)	☒ Readily available	☐ Up to date	☐ N/A

Remarks: Monitoring per the 2007 Sampling and Analysis Plan, Groundwater Treatment Plant and Well Fields (Shaw, 2007). Records maintained at GWTP. Quarterly Evaluation Reports maintained in Department of Army, Administrative Record.

10. Daily Access/Security Logs ☒ Readily available ☒ Up to date ☐ N/A

Remarks: Daily Sign In Sheet at Groundwater Treatment Plant. LHAAP-18/24 has perimeter fence. Access road to Groundwater Treatment Plant and site is gated with code key for entry. Warning signs are posted at the gate as well as at the plant and site.

IV. O&M COSTS

1. O&M Organization

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☒ Other (Example: Contractor for U.S. Army Corps of Engineers)

(Please see the appropriate sections of the Five-Year Review Report (2013) for cost information)

2. O&M Cost Records

☐ Readily available ☐ Up to date
☒ Funding mechanism/agreement in place
Original O&M cost estimate ☐ Breakdown attached

Total annual cost by year for review period, if available

From ________ to____ ______ ☐ Breakdown attached
Date Date Total cost

From ________ to____ ______ ☐ Breakdown attached
Date Date Total cost

From ________ to____ ☐ Breakdown attached
Date Date Total cost

From ________ to____ ______ ☐ Breakdown attached
Date Date Total cost

From ________ to____ ______ ☐ Breakdown attached
Date Date Total cost

3. Unanticipated or Unusually High O&M Costs During Review Period

Describe costs and reasons:
1. Maintenance and repair costs at the GWTP have increased due to system age.
2.
3.
4.
5.

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. Fencing damaged ☐ Location shown on map ☐ Gates secure ☐ N/A

Remarks: Fencing of site restricted area complete around perimeter. Good condition with no noticeable breeches. A few areas of vegetation need clearing / maintenance. Site access road gate unlocked with paved road to GWTP and site locked. Access by password and key.

B. Other Access Restrictions

1. Signs and other security measures ☐ Location shown on map ☐ N/A

Remarks: Signage on fencing and gate needs checking and replacement. Infrequent signage along perimeter fence of site.

C. Institutional Controls

1. Implementation and enforcement

Site conditions imply ICs not properly implemented	☐ Yes	☒ No	☐ N/A
Site conditions imply ICs not being fully enforced	☐ Yes	☒ No	☐ N/A

Type of monitoring (e.g., self-reporting, drive by) Self reporting
Frequency Common to occur daily.
Responsible party/agency U.S. Army
Contact

Name	Title	Date	Phone no.
Ms. Rose M. Zeiler (PhD)	Site Manager	NA	(479)635-0110

Reporting is up-to-date	☒ Yes	☐ No	☐ N/A
Reports are verified by the lead agency	☐ Yes	☐ No	☒ N/A
Specific requirements in deed or decision documents have been met	☐ Yes	☐ No	☒ N/A
Violations have been reported	☐ Yes	☐ No	☒ N/A
Other problems or suggestions:	☐ Report attached		

2. Adequacy ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A

Remarks: Sites under control of U.S. Army. Construction activities at the Base must also be cleared by the environmental group to address any potential exposure issues. Site LHAAP 18/24 is not included in the revised 2007 or 2013 LUC plans.

D. General

1. Vandalism/trespassing ☐ Location shown on site map ☒ No vandalism evident

Remarks: Minor trespassing violations near site but none known within the site area.

V.D ACCESS AND INSTITUTIONAL CONTROLS (continued)

2. Land use changes on site ☐ N/A
Remarks: None.

3. Land use changes off site ☒ N/A
Remarks: None, Caddo Lake National Wildlife Refuge_

VI. GENERAL SITE CONDITIONS

A. Roads ☒ Applicable ☐ N/A

1. Roads damaged ☐ Location shown on site map ☒ Roads adequate ☐ N/A
Remarks: No Access Issues.

B. Other Site Conditions
Remarks: General Site Condition is Excellent.

VII. LANDFILL COVERS ☐ Applicable ☒ N/A

A. Landfill Surface

1. Settlement (Low spots) ☐ Location shown on site map ☐ Settlement not evident
Arial extent Depth
Remarks:

2. Cracks ☐ Location shown on site map ☐ Cracking not evident
Lengths Widths Depths
Remarks:

3. Erosion ☐ Location shown on site map ☐ Erosion not evident
Arial extent Depth
Remarks:

VII.A LANDFILL COVERS (continued)		
4. Holes Arial extent Remarks:	☐ Location shown on site map Depth	☐ Holes not evident
5. Vegetative Cover ☐ Grass ☐ Trees/Shrubs (indicate size and locations on a diagram) Remarks:	☐ Cover properly established	☐ No signs of stress
6. Alternative Cover (armored rock, concrete, etc.) Remarks:	☐ N/A	
7. Bulges Arial extent Remarks:	☐ Location shown on site map Depth	☐ Bulges not evident
8. Wet Areas/Water Damage ☒ Wet areas ☐ Ponding ☐ Seeps ☐ Soft subgrade Remarks: _Wet areas in drainage swales, western area near Sprinkler System	☐ Wet areas/water damage not evident ☐ Location shown on site map ☐ Location shown on site map ☐ Location shown on site map ☐ Location shown on site map	 ☐ Arial extent ☐ Arial extent ☐ Arial extent ☐ Arial extent
9. Slope Instability ☐ Slides Arial extent Remarks:	☐ Location shown on site map	☐ No evidence of slope instability
B. Benches	☐ Applicable	☐ N/A
1. Flows Bypass Bench Remarks:	☐ Location shown on site map	☐ N/A or okay

VII.B LANDFILL COVERS (continued)		
2. Bench Breached Remarks:	☐ Location shown on site map	☐ N/A or okay
3. Bench Overtopped Remarks:	☐ Location shown on site map	☐ N/A or okay
C. Letdown Channels	☐ Applicable	☒ N/A
1. Settlement Arial extent Remarks:	☐ Location shown on site map Depth	☐ No evidence of settlement
2. Material Degradation Material type Remarks:	☐ Location shown on site map Arial extent	☐ No evidence of degradation
3. Erosion Arial extent Remarks:	☐ Location shown on site map Depth	☐ No evidence of erosion
4. Undercutting Arial extent Remarks:	☐ Location shown on site map Depth	☐ No evidence of undercutting
5. Obstructions Type ☐ Location shown on site map Size Remarks:	Arial extent	☐ No obstructions
6. Excessive Vegetative Growth ☐ No evidence of excessive growth ☐ Vegetation in channels does not obstruct flow ☐ Location shown on site map Remarks:	Type Arial extent	

VII. LANDFILL COVERS (continued)			
D. Cover Penetrations		☐ Applicable	☒ N/A
1. Gas Vents	☐ Active	☐ Passive	
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs maintenance	☐ N/A
Remarks:			
2. Gas Monitoring Probes			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☐ N/A
Remarks:			
3. Monitoring Wells (within surface area of landfill)			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☐ N/A
Remarks:			
4. Leachate Extraction Wells			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☐ N/A
Remarks:			
5. Settlement Monuments	☐ Located	☐ Routinely surveyed	☐ N/A
Remarks:			
E. Gas Collection and Treatment		☐ Applicable	☐ N/A
1. Gas Treatment Facilities			☐ N/A
☐ Flaring	☐ Thermal destruction	☐ Collection for reuse	
☐ Good condition		☐ Needs Maintenance	
Remarks:			
2. Gas Collection Wells, Manifolds, and Piping			☐ N/A
☐ Good condition		☐ Needs Maintenance	
Remarks:			
3. Gas Monitoring Facilities (e.g., gas monitoring of adjacent homes or buildings)			☐ N/A
☐ Good condition		☐ Needs Maintenance	
Remarks:			

VII. LANDFILL COVERS (continued)			
F. Cover Drainage Layer		☐ Applicable	☐ N/A
1. Outlet Pipes Inspected Remarks:		☐ Functioning	☐ N/A
2. Outlet Rock Inspected Remarks:		☐ Functioning	☐ N/A
G. Detention/Sedimentation Ponds		☐ Applicable	☐ N/A
1. Siltation Remarks:	Arial extent Siltation not evident	Depth	☐ N/A
2. Erosion Remarks:	Arial extent Erosion not evident	Depth	
3. Outlet Works Remarks:	☐ Functioning	☐ N/A	
4. Dam Remarks:	☐ Functioning	☐ N/A	
H. Retaining Walls	☐ Applicable	☐ N/A	
1. Deformations Horizontal displacement Rotational displacement Remarks:	☐ Location shown on site map	Vertical displacement	☐ Deformation not evident
2. Degradation Remarks:	☐ Location shown on site map		☐ Degradation not evident

VII. LANDFILL COVERS (continued)			
I. Perimeter Ditches/Off-Site Discharge		☐ Applicable	☐ N/A
1. Siltation Arial extent Remarks:	☐ Location shown on site map	Depth	☒ Siltation not evident
2. Vegetative Growth ☐ Vegetation does not impede flow Arial extent Remarks:	☐ Location shown on site map	Type	☐ N/A
3. Erosion Arial extent Remarks:	☐ Location shown on site map	Depth	☐ Erosion not evident
4. Discharge Structure Remarks:	☐ Functioning		☐ N/A

VIII. VERTICAL BARRIER WALLS		☐ Applicable	☒ N/A
1. Settlement Arial extent Remarks: Liners at Two ICTs (12 and 13) have HDPE liners on the western and northern sides, respectively. These form impermeable barriers between the ICTs and Harrison Bayou to inhibit the contamination from migrating towards Harrison Bayou and to focus the groundwater extraction within the fenced area.	☐ Location shown on site map ☐ Depth		☒ Settlement not evident
2. Performance Monitoring ☐ Performance not monitored Frequency Head differential Remarks:	Type of monitoring ☒ N/A	☐ Evidence of breaching	
IX. GROUNDWATER/SURFACE WATER REMEDIES	☒ Applicable	☐ N/A	
A. Groundwater Extraction Wells, Pumps, and Pipelines	☒ Applicable	☐ N/A	
1. Pumps, Wellhead Plumbing, and Electrical ☐ Good condition	☐ All required wells located	☒ Needs maintenance	☐ N/A
Remarks: Maintenance and optimization being conducted at time of site visit.			

IX. GROUNDWATER/SURFACE WATER REMEDIES ☒ Applicable ☐ N/A

2. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances

☒ Good condition ☒ Needs maintenance

Remarks: Maintenance and optimization being conducted at time of site visit.

3. Spare Parts and Equipment

☒ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks: Standard items readily available, specialized items/supplies procured within 24 to 28 hours.

B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ☒ N/A

1. Collection Structures, Pumps, and Electrical

☐ Good condition ☐ Needs maintenance

Remarks:

2. Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances

☐ Good condition ☐ Needs maintenance

Remarks:

3. Spare Parts and Equipment

☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided

Remarks:

C. Treatment System ☒ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)

☒ Metals removal ☐ Oil/water separation ☐ Bioremediation

☒ Air stripping ☒ Carbon adsorbers

☒ Filters

☒ Additive (e.g., chelation agent, flocculent)

☒ Others

☒ Good condition ☐ Needs maintenance

☒ Sampling ports properly marked and functional

☒ Sampling/maintenance log displayed and up to date

☒ Equipment properly identified

☐ Quantity of ground water treated annually

☐ Quantity of surface water treated annually

Remarks:

IX.C. GROUND WATER/SURFACE WATER REMEDIES (continued)

2. Electrical Enclosures and Panels (Properly rated and functional)
☐ N/A ☒ Good condition ☐ Needs maintenance
Remarks:

3. Tanks, Vaults, Storage Vessels
☐ N/A ☒ Good condition ☒ Proper secondary containment ☒ Needs maintenance
Remarks: Concerns from last five-year review have been corrected. Slight rust corrosion noticed on Activated Carbon Vessels, PK200B Tank, and below PK140 Influent Holding Tank flange. Generally Well Maintained Conditions at Groundwater Treatment Plant.

4. Discharge Structure and Appurtenances
☐ N/A ☒ Good condition ☐ Needs maintenance
Remarks:

5. Treatment Building(s)
☐ N/A ☒ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks:

6. Monitoring Wells (Pump and treatment remedy)
☐ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☐ Good condition
☒ All required wells located ☒ Needs maintenance ☐ N/A
Remarks: Site Monitoring Well Condition Survey Recently Conducted (December 19, 2012). Monitoring Wells will be reconditioned as appropriate.

D. Monitoring Data

1. Monitoring Data
☒ Is routinely sampled on time ☐ Is of acceptable quality
data reports not available

2. Monitoring Data Suggests
☐ Groundwater plume is effectively contained ☒ Contaminant concentrations are declining (with minor exceptions, see text of Five-Year Review report

E. Monitored Natural Attenuation ☒ Applicable ☐ N/A

1. Monitoring Wells (Natural attenuation remedy)
☐ Properly secured/locked ☒ Functioning ☒ Routinely sampled ☐ Good condition
☒ All required wells located ☒ Needs maintenance ☐ N/A
Remarks: see comment in 3.6 Monitoring Wells (Pump and treatment remedy) above.

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

The IRA was intended to protect human health and the environment via waste removal and groundwater treatment. Remedial Action Objectives (RAOs), in accordance with the 1995 IRA ROD have been met by mitigating potential risks posed by high concentrations of chlorinated solvents and heavy metals in source material present prior to the IRA and in shallow groundwater. Excavation of source material and contaminated soil ~30,000 yd3 (February 1997) greatly reduced contaminant mass. The Remedial Action Construction completion date was August 31, 1999. The interceptor collection trench (ICT) system is 14 sections, from 100 to 1,300 ft in length, (~5,000 linear feet) and ~25 to 55 ft deep within and around 3 sides of the Burning Ground. Trenches are as deep as the confining, shallow GW zone clay layer. Twenty-eight sumps and pumps remove water thru dual wall containment piping to the GWTP influent tank. Trench water level probes activate or deactivate electric pumps to maximize groundwater capture. ROD exceptions are that 8 vertical extraction wells were not installed. A 2010 Letter and Final Explanation of Significant Differences, presents a synopsis of the ROD changes. Actual depths of ICTs are unknown.

The groundwater extraction and treatment protects the environment and human health by further reducing contaminant mass and exerting local, hydraulic groundwater control. The Groundwater Treatment Plant (GWTP) began operation in January 1997. In 1998, perchlorate was discovered in groundwater and a Fluidized Bed Reactor began biological treatment in April 2001. Reinjection of treated groundwater began in 2007. Occasional exceedances of the perchlorate discharge limit have occurred, otherwise, the system appears to be meeting objectives. In practice, O&M activities at LHAAP-012, -016, and -018/024 are intertwined.

Water levels, groundwater-flow direction and gradients have changed since implementation of the IRA in 1994 and reinjection of treated water in 2007. Drought and removal of water for treatment has affected the locations of groundwater highs and caused overall groundwater-levels to decline about 8 to 9 ft from 1994 to 2006. After reinjection of treated water (2007), groundwater-levels have risen (2009 measurements) to within 2 ft of the 1994 levels. The reinjection of water into ICT 9 in the southeast part of LHAAP–18/24 might be causing groundwater to flow towards the southeast.

Comparison of contaminant data indicates contaminants have not spread dramatically and concentrations have been reduced. The methylene chloride (MC), TCE and perchlorate plumes have fluctuated. The MC plume appears to have moved to the south since reinjection began. In the northeast and northwest border areas the MC plume appears contained on-site, whereas in the southwest border area there appears to be limited offsite migration. The reasons contaminates continue to be detected outside LHAAP–18/24 are not fully known but may be caused by some contaminated groundwater bypassing the ICTs or possibly another offsite source. There does not seem to be on-going migration of TCE offsite. Residual Perchlorate in northwest and southwest border areas may continue as sources. In intermediate and deep monitoring wells, Perchlorate concentrations have been decreasing and MC is generally not present or attenuated. Concentrations of MC and TCE can vary by orders of magnitude between sampling events, as rain appears to influence TCE concentrations. The IRA appears to have minimized contamination reaching Harrison Bayou.

IRA measures were not intended to be a final remedy. All components of the final remedy (enhanced LUCs, in situ bioremediation, biobarriers and MNA) are still in the design phase. The Feasibility Study presently under way will evaluate the existing groundwater extraction and treatment, as well as other technologies.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

The groundwater extraction and treatment system has been functioning adequately, but often at a reduced capacity. The system has recently undergone major repairs, has been operating much more efficiently and is in the process of being optimized. Injection of water in two injection locations (ICT-6 and ICT-9) did not seem to increase efficiency of capture.

XI. OVERALL OBSERVATIONS (continued)

C. Early Indicators of Potential Remedy Failure

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future.

The O&M cost variances have occurred mainly due to age of equipment. Note changes in Section A.

D. Opportunities for Optimization

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

Monitoring wells are recommended for assessment and reconditioning as well as additional monitoring to assess plume capture. The installation of intermediate and deep monitoring wells at select locations, adjacent to existing shallow wells, would provide data to determine vertical gradients and extent of potential contamination.

Groundwater level maps indicate the potential for transport of contaminated water in all directions from groundwater highs so additional sampling of monitoring wells within LHAAP-18/24 and just outside contaminant liners and ICTs on a regular basis is recommended to monitor for potential bypassing and continue to determine concentrations and locations of contaminant plumes.

Individual Site Notes – Field Reconnaissance

Longhorn Army Ammunition Plant, Karnack, TX.

2013 Five Year Review

Site: LHAAP-012 **Date: 12/17/12**

Field Team: Dave Wacker, Gretchen McDonnell, Dave Gammans

Findings:	Remedy:
1. Unlocked Gate:	Needs New Lock, Securing
2. Numerous Subsidence Areas Marked with flagging:	GPS Coordinates Recorded
a. Central ~10'X12'	
b. West Edge three small areas ~10X20' and two combined at ~8'X40'	
c. North End ~40'X40'	
d. Northwest Mower ruts ~10'X30'.	
Most areas ~ 1 to 1.5 ft deep.	Backfill, Tamper, Regrade, Vegetate
3. Minor washout surface soil and grasses on east edge.	Grade, Vegetate
4. East Edge fence line old, former animal burrow.	Check for activity, backfill and grade
5. Monitoring Well Identification, Condition – Out of date	Confirm IDs, repainting, remarking, some locks, hinge repair (see well list)

Site: LHAAP-016 **Date: 12/17/12**

Field Team: Dave Wacker, Gretchen McDonnell, Dave Gammans

Findings:	Remedy:
1. Access Unrestricted @ Gate:	Needs Barbed Wire to limit access around gate
2. Signage Missing Along Fence line	Replace
3. Few, Small Subsidence Areas Marked with flagging	
a. Central, West 30'X30'	
b. Central, North ~40X10'	
Areas ~ 0.5 ft deep.	Backfill, Tamper, Regrade, Vegetate
4. Minor erosion surface soil, sparse vegetation esp.west edge	Grade, Vegetate
a. West 20'X15' and 50'X30'	
b. East 15'X30' and 10'X50'	
c. Northeast, Slight	
d. North, Slight	
5. Animal burrow. East Central near swale	Check for activity, backfill and grade
6. Monitoring Well Identification, Condition	Confirm IDs, repainting, remarking, growth clearing, some pad repairs, some locks, hinge repair (see well list)

Site: LHAAP-018/ 024 **Date: 12/19 and 20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Unlocked Gate	Needs New Lock, Securing
2. Gate Signage Illegible	Replace with new signs
3. Signage Missing Along Fence line	Replace
4. Few areas of Fence Have Excessive Vegetation	Clearing / Maintenance
5. Monitoring Well Identification, Condition – Out of date	Inspection, Confirm IDs, Repainting, Remarking, Locks, Repair or Abandon as needed

Site: Groundwater Treatment Plant (GWTP) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Rust Corrosion on Activated Carbon Vessels	Recondition, Repaint
2. Rust Corrosion on PK200B Tank	Recondition, Repaint
3. Rust Residue Below PK140 Influent Holding Tank Flange	Recondition, Repaint
4. System Optimization	Engineering Review
5. Level Probe Hydrochloric Acid Tank	Needs Engineering Review, Repair

Site: Former Pistol Range (LHAAP-004-R-01) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Daily Access/Security Logs	Review LUC Management Plan and Determine Fish and Wildlife Service and/or US Army Responsibility
2. Missing Signage, Gate Access	Review Plan As Above
3. Former Monitoring Well Abandonment	Research, Confirm, Possible Search

Site: Former Acid Plant (LHAAP-049) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Daily Access/Security Logs	Review LUC Management Plan and Determine Fish and Wildlife Service and/or US Army Responsibility
2. Missing Signage, Access	Review Plan As Above
3. Monitoring Wells Identification, Condition	Research, Confirm IDs, Repainting, Remarking, Growth Clearing, Repair or Abandon as needed

APPENDIX F6: Photographs

AECOM

Photo Log

Longhorn Army Ammunition Plant, Karnack, TX.

2013 Five Year Review

Photo #	Date	Site	Description
101_1114.JPG	12/19/12	LHAAP-018/024	Central Site Area Looking North
101_1115.JPG	12/19/12	"	Central Site Area, Interception Collection Trench and Phyto Remediation in Distance
101_1116.JPG	12/19/12	"	Typical Monitoring Well and Phyto Remediation Area Looking Southeast
101_1117.JPG	12/19/12	"	Former Unlined Evaporation Pond (UEP) Location Looking West
101_1118.JPG	12/19/12	"	Phyto Remediation Area Looking South
101_1119.JPG	12/19/12	"	Fence Line and Typical Monitoring Well Looking Southeast
101_1120.JPG	12/19/12	"	Interceptor Collection Trench Extraction Unit
101_1121.JPG	12/19/12	"	Interceptor Collection Trenches Along Northeast Border
101_1122.JPG	12/19/12	"	Remains of Centrally Located Building
101_1123.JPG	12/19/12	"	Gate and Entrance Road to Lined Settling Pond Looking East
101_1124.JPG	12/19/12	"	Lined Settling Pond Looking West
101_1125.JPG	12/19/12	"	Edge of Lined Settling Pond Showing Slight Erosion
101_1126.JPG	12/19/12	"	Storage Building North of Lined Settling Pond
101_1127.JPG	12/19/12	"	Buildings near Lined Settling Pond Looking North
101_1128.JPG	12/19/12	"	Slight Erosion Along Edge of Lined Settling Pond
101_1146.JPG	12/20/12	LHAAP-018/024	Entrance Gate and Access Road to Site Looking North
101_1147.JPG	12/20/12	"	Warning Signs at Gate Entrance
101_1148.JPG	12/20/12	"	Southeast Fence Line Around Site
101_1149.JPG	12/20/12	"	Central Site Area, Phyto Remediation Area in Distance
101_1150.JPG	12/20/12	"	Interceptor Collection Trench to West
101_1151.JPG	12/20/12	"	Southwest Fence Line Around Site, Looking Northwest
101_1152.JPG	12/20/12	"	Drainage Swale Near Southwest Fence Line
101_1153.JPG	12/20/12	"	Close-up of Drainage Swale
101_1154.JPG	12/20/12	"	Northwest Fence Line with Interceptor Collection Trench Behind
101_1155.JPG	12/20/12	"	Central Site Area Looking North
101_1156.JPG	12/20/12	"	Drainage Swale and Sprinklers Near Access Road Looking Northwest
101_1157.JPG	12/20/12	"	Close-up of Drainage Swale
101_1158.JPG	12/20/12	"	General Site Area with Interceptor Collection Trenches Looking North
101_1159.JPG	12/20/12	"	General Site Area with Interceptor Collection Trenches Looking North
101_1160.JPG	12/20/12	"	Interceptor Collection Trenches In Northern Area
101_1161.JPG	12/20/12	"	Central Drum and Supplies Area

Weather: overcast, moderate wind, temps low to hi 50's °F, 12/20/12 sun, slight wind, hi 50's °F

Field Team: David Gammans, Scott Beesinger

Camera Details: Kodak EasyShare M5350, 16 MP

Photograph Files Location: c:\Users\GammansD\Longhorn 5yr\Travel\field work forms\Completed Site Forms\12-19-2012 and \12-20-2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/20/2012


CHECK WITH FOREMAN
OR
WORKING LEADER
BEFORE ENTERING
12/20/2012


12/20/2012


12/20/2012


12/20/2012


12/20/2012


12/20/2012


12/20/2012


12/20/2012


12/20/2012


12/20/2012


12/20/2012


12/20/2012


12/20/2012


12/20/2012


12/20/2012

APPENDIX G: LHAAP-49 Supporting Documents

APPENDIX G1: Documents Reviewed

Documents Reviewed for LHAAP-49

Jacobs Engineering Group, Inc. (Jacobs), 2002. *Final Remedial Investigation Report Addendum for the Group 2 Sites Remedial Investigation Report, Site 49*, St. Louis, Missouri. February.

Jacobs, 2002. *Final Report - Baseline Human Health and Screening Ecological Risk Assessment: - Volume 1: Report, for Group 2 Sites, Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake, at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, AR 2002 Vol 3 of 4 B, 029298 - 029954, 2002-vol. 03 (of 04) JacobsBaselineHlth.pdf. August.

Plexus Scientific Corp., 2005. *Environmental Site Assessment, Phase I and II Report, Final, Production Areas, Longhorn Army Ammunition Plant, Karnack, Texas*. February.

Shaw, 2007. *Final Installation-Wide Baseline Ecological Risk Assessment, Volume I*, Longhorn Army Ammunition Plant, Karnack, TX, AR 2007 Vol 10 of 25 A, 00049542 - 00050415, 2007 Final-Instln-Baseline-EcoVol10of25.pdf. November.

Shaw, 2009. *Final Site Evaluation Report, LHAAP-49, Former Acid Storage Area, Longhorn Army Ammunition Plant, Karnack, Texas*. June.

Texas Commission on Environmental Quality (TCEQ), 1998. *Interoffice Memorandum from Ronald R. Pedde to Remediation Division Staff regarding implementation of the existing risk reduction rules (a.k.a. TNRCC Consistency Memorandum)*. July.

TCEQ, 2006. *Texas Risk Reduction Rules (30TAC§335) as updated through April*. December. Access website: http://www.tceq.texas.gov/remediation/rrr.html.

TCEQ, 2008. Email from Fay Duke to Stephen Tzhone/USEPA, Subject: *LHAAP-49 Soil Removal, Austin, Texas*. September 22nd.

U.S. Army, 2005. *Evaluations of Select Metals Detections in the West Further Investigation Area, Longhorn Army Ammunition Plant, Texas, Revision*. February.

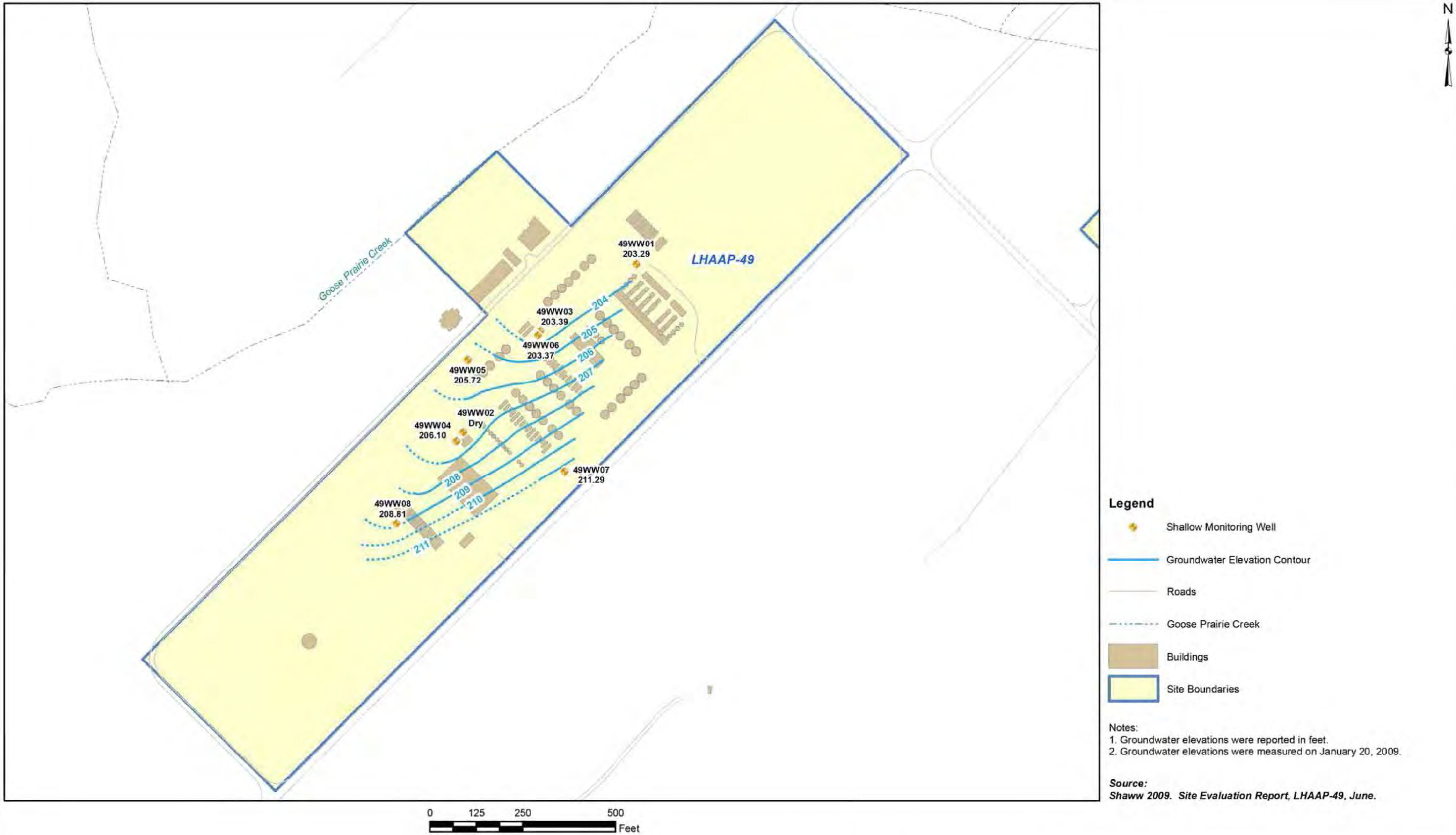
U.S. Army, 2010. *Final Proposed Plan for LHAAP-49, Former Acid Storage Area, Longhorn Army Ammunition Plant, Karnack, Texas*. January.

U.S. Army Environmental Hygiene Agency, 1987. *Final Groundwater Contamination Survey No. 38-26-0851-89, Evaluation of Solid Waste Management Units, Longhorn Army Ammunition Plant, Karnack, Texas*. May.

U.S. Army Toxic and Hazardous Materials Agency, 1980. *Installation Assessment of Longhorn Army Ammunition Plant, Report No. 150*. February.

U.S. Environmental Protection Agency, 1994. *National Oil and Hazardous Substances Pollution Contingency Plan*, 40 *Code of Federal Regulations* Part 300, 59 *Federal Register* 47384. October.

APPENDIX G2: Groundwater Elevation Maps



Legend

Shallow Monitoring Well

Groundwater Elevation Contour

Roads

Goose Prairie Creek

Buildings

Site Boundaries

Notes:
1. Groundwater elevations were reported in feet.
2. Groundwater elevations were measured on January 20, 2009.

Source:
Shaww 2009. Site Evaluation Report, LHAAP-49, June.

AECOM

Figure G2-1
Groundwater Elevation Map - Shallow Zone
LHAAP-49
Longhorn Army Ammunition Plant
Karnack, Texas

60256135

January 2013

APPENDIX G3: Five-Year Review Site Inspection Checklist

FIVE-YEAR REVIEW SITE INSPECTION CHECKLIST

Information may be completed by hand and attached to the five-year review report as supporting documentation of site status. "N/A" refers to "not applicable."

I. SITE INFORMATION	
Site Name: Longhorn Army Ammunition Plant Site: LHAAP-049 (Former Acid Plant)	Date of Inspection: Dec. 19, 2012
Location and Region: Karnack, TX; EPA Region 6	**EPA ID: TX6213820529**
Agency, office or company leading the five-year review: AECOM under contract to the U.S. Army	Weather/temperature: Overcast, moderate wind, temps low to hi 50's °F.
Remedy Includes: (Check all that apply) ☐ Landfill cover/containment ☒ Access controls ☒ Institutional controls ☐ Ground water pump and treatment NA Surface water collection and treatment ☒ Other – No Further Action	
Attachments: ☐ Inspection team roster attached Inspection Team Members: David D. Gammans, Scott Beesinger	☐ Site map attached

II. INTERVIEWS (Check all that apply)		
1. O&M Site Manager Name, Affiliation: Scott Beesinger	**Title** O&M Site Manager	**Date** Dec. 20, 2012
Interviewed: ☐ by mail ☒ at office ☐ by phone Problems, suggestions: ☒ Report attached (Refer to Appendix I)		Phone no. (903)217-9954
2. O&M Staff Name, Affiliation: Ray Wagner	**Title** O&M Staff	**Date** Dec. 20, 2012
Interviewed: ☐ by mail ☒ at office ☐ by phone Problems, suggestions: ☐ Report attached		Phone no. (903)679-3448

II. INTERVIEWS (continued)

3. Local regulatory authorities and response agencies (i.e.; State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.). Fill in all that apply.

Agency
Contact ______ ______ ______ ______
Name Title Date Phone no.

Problems, suggestions: ☒ Report attached (Refer to Appendix I)

Agency ______
Contact ______ ______ ______ ______
Name Title Date Phone no.

Problems, suggestions: ☒ Report attached See Interview Record (Refer to Appendix I)

4. Other interviews (optional) ☒ Report attached to Five-Year Review Report (Refer to Appendix I)

1.
2.
3.
4.
5.

III. ONSITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. O&M Documents

☐ O&M Manual (see below)	☐ Readily available	☐ Up to date	☒ N/A
☐ As-built drawings	☐ Readily available	☐ Up to date	☒ N/A
☐ Maintenance logs	☐ Readily available	☐ Up to date	☒ N/A

Remarks:

2. Site-Specific Health and Safety Plan	☐ Readily available	☐ Up to date	☒ N/A
☐ Contingency plan/emergency response plan	☐ Readily available	☐ Up to date	☐ N/A

Remarks:

III. ONSITE DOCUMENTS & RECORDS VERIFIED (continued)			
3. O&M and OSHA Training Records	☐ Readily available	☐ Up to date	☒ N/A
Remarks: ________________			
4. Permits and Service Agreements			
☐ Air discharge permit	☐ Readily available	☐ Up to date	☒ N/A
☐ Effluent discharge	☐ Readily available	☐ Up to date	☒ N/A
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	☒ N/A
☐ Other permits	☐ Readily available	☐ Up to date	☒ N/A
Remarks:			
5. Gas Generation Records	☐ Readily available	☐ Up to date	☒ N/A
Remarks:			
6. Settlement Monument Records	☐ Readily available	☐ Up to date	☒ N/A
Remarks:			
7. Ground Water Monitoring Records	☒ Readily available	☐ Up to date	☐ N/A
Remarks: U.S. Army Administrative Record (Six Monitoring Wells on site)			
8. Leachate Extraction Records	☐ Readily available	☐ Up to date	☒ N/A
Remarks:			
9. Discharge Compliance Records			
☐ Air	☐ Readily available	☐ Up to date	☒ N/A
☐ Water (effluent)	☐ Readily available	☐ Up to date	☒ N/A
Remarks			
10. Daily Access/Security Logs	☐ Readily available	☐ Up to date	☒ N/A
Remarks:			

IV. O&M COSTS

1. O&M Organization

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☒ Other (Example: Contractor for U.S. Army Corps of Engineers)

(Please see Section 4.0 of the Five-Year Review Report (2013) for cost information)

2. O&M Cost Records

☐ Readily available ☐ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate ___________ ☐ Breakdown attached

Total annual cost by year for review period, if available
(State unit here).

From __Month year______ to ______ ______ ☐ Breakdown attached
Date Date Total cost

From __________ to ______ ______ ☐ Breakdown attached
Date Date Total cost

From __________ to ______ ______ ☐ Breakdown attached
Date Date Total cost

From __________ to ______ ______ ☐ Breakdown attached
Date Date Total cost

From __________ to ______ ______ ☐ Breakdown attached
Date Date Total cost

3. Unanticipated or Unusually High O&M Costs During Review Period

Describe costs and reasons:
1. ____
2. ____
3. ____
4. ____
5. ____

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. Fencing damaged ☐ Location shown on map ☐ Gates secure ☒ N/A

Remarks: No fencing present. Paved roads around site perimeter.

B. Other Access Restrictions

1. Signs and other security measures ☐ Location shown on map ☐ N/A

Remarks: Fish and Wildlife Service and Department of Army Warning Signs on site. Signs prohibit unauthorized and/or public entry.

C. Institutional Controls

1. Implementation and enforcement

Site conditions imply ICs not properly implemented ☐ Yes ☒ No ☐ N/A

Site conditions imply ICs not being fully enforced ☐ Yes ☒ No ☐ N/A

Type of monitoring (e.g., self-reporting, drive by)

Frequency

Responsible party/agency NA

Contact

Name	Title	Date	Phone no.

Reporting is up-to-date ☐ Yes ☐ No ☐ N/A

Reports are verified by the lead agency ☐ Yes ☐ No ☐ N/A

Specific requirements in deed or decision documents have been met ☐ Yes ☐ No ☐ N/A

Violations have been reported ☐ Yes ☐ No ☐ N/A

Other problems or suggestions: ☐ Report attached

2. Adequacy ☒ ICs are adequate ☐ ICs are inadequate ☒ N/A

Remarks: All construction activities at the Base must also be cleared by the environmental group to address any potential exposure issues. LHAAP-49 is a component of the revised 2007 and new 2013 LUC plans.

D. General

1. Vandalism/trespassing ☐ Location shown on site map ☒ No vandalism evident

Remarks:

V.D ACCESS AND INSTITUTIONAL CONTROLS (continued)

2. Land use changes on site ☐ N/A
Remarks: None.

3. Land use changes off site ☐ N/A
Remarks: None, Caddo Lake Wildlife Refuge

VI. GENERAL SITE CONDITIONS

A. Roads ☒ Applicable ☐ N/A

1. Roads damaged ☐ Location shown on site map ☒ Roads adequate ☐ N/A
Remarks: Dirt roadway along northern edge of site. Paved roadways around site perimeter.

B. Other Site Conditions

Remarks: Piney woodlands, few concrete foundations/saddles, two building shells and debris remain. Monitoring wells on-site.

VII. LANDFILL COVERS ☐ Applicable ☒ N/A

A. Landfill Surface

1. Settlement (Low spots) ☐ Location shown on site map ☐ Settlement not evident
Arial extent Depth
Remarks:

2. Cracks ☐ Location shown on site map ☐ Cracking not evident
Lengths Widths Depths
Remarks:

3. Erosion ☐ Location shown on site map ☐ Erosion not evident
Arial extent Depth
Remarks:

VII.A LANDFILL COVERS (continued)

4. Holes ☐ Location shown on site map ☐ Holes not evident
Arial extent Depth
Remarks:

5. Vegetative Cover ☐ Grass ☐ Cover properly established ☐ No signs of stress

☐ Trees/Shrubs (indicate size and locations on a diagram)
Remarks:

6. Alternative Cover (armored rock, concrete, etc.) ☐ N/A
Remarks:

7. Bulges ☐ Location shown on site map ☐ Bulges not evident
Arial extent Depth

Remarks:

8. Wet Areas/Water Damage ☐ Wet areas/water damage not evident

☐ Wet areas	☐ Location shown on site map	☐ Arial extent
☐ Ponding	☐ Location shown on site map	☐ Arial extent
☐ Seeps	☐ Location shown on site map	☐ Arial extent
☐ Soft subgrade	☐ Location shown on site map	☐ Arial extent

Remarks:

9. Slope Instability ☐ Slides ☐ Location shown on site map ☐ No evidence of slope instability

Arial extent

Remarks:

B. Benches ☐ Applicable ☐ N/A

1. Flows Bypass Bench ☐ Location shown on site map ☐ N/A or okay

Remarks:

VII.B LANDFILL COVERS (continued)		
2. **Bench Breached** Remarks:	☐ Location shown on site map	☐ N/A or okay
3. **Bench Overtopped** Remarks:	☐ Location shown on site map	☐ N/A or okay
C. **Letdown Channels**	☐ Applicable	☐ N/A
1. **Settlement** Arial extent Remarks:	☐ Location shown on site map Depth	☐ No evidence of settlement
2. **Material Degradation** Material type Remarks:	☐ Location shown on site map Arial extent	☐ No evidence of degradation
3. **Erosion** Arial extent Remarks:	☐ Location shown on site map Depth	☐ No evidence of erosion
4. **Undercutting** Arial extent Remarks:	☐ Location shown on site map Depth	☐ No evidence of undercutting
5. **Obstructions** Type ☐ Location shown on site map Size Remarks:	Arial extent	☐ No obstructions
6. **Excessive Vegetative Growth** ☐ No evidence of excessive growth ☐ Vegetation in channels does not obstruct flow ☐ Location shown on site map Remarks:	Type Arial extent	

VII. LANDFILL COVERS (continued)			
D. Cover Penetrations		☐ Applicable	☐ N/A
1. Gas Vents	☐ Active	☐ Passive	
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs maintenance	☐ N/A
Remarks:			
2. Gas Monitoring Probes			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☐ N/A
Remarks:			
3. Monitoring Wells (within surface area of landfill)			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☐ N/A
Remarks:			
4. Leachate Extraction Wells			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☐ N/A
Remarks:			
5. Settlement Monuments	☐ Located	☐ Routinely surveyed	☐ N/A
Remarks:			
E. Gas Collection and Treatment		☐ Applicable	☐ N/A
1. Gas Treatment Facilities			☐ N/A
☐ Flaring	☐ Thermal destruction	☐ Collection for reuse	
☐ Good condition		☐ Needs Maintenance	
Remarks:			
2. Gas Collection Wells, Manifolds, and Piping			☐ N/A
☐ Good condition		☐ Needs Maintenance	
Remarks:			
3. Gas Monitoring Facilities (e.g., gas monitoring of adjacent homes or buildings)			☐ N/A
☐ Good condition		☐ Needs Maintenance	
Remarks:			

VII. LANDFILL COVERS (continued)			
F. Cover Drainage Layer		☐ Applicable	☐ N/A
1. Outlet Pipes Inspected Remarks:		☐ Functioning	☐ N/A
2. Outlet Rock Inspected Remarks:		☐ Functioning	☐ N/A
G. Detention/Sedimentation Ponds		☐ Applicable	☐ N/A
1. Siltation Remarks:	Arial extent Siltation not evident	Depth	☐ N/A
2. Erosion Remarks:	Arial extent Erosion not evident	Depth	
3. Outlet Works Remarks:	☐ Functioning	☐ N/A	
4. Dam Remarks:	☐ Functioning	☐ N/A	
H. Retaining Walls	☐ Applicable	☐ N/A	
1. Deformations Horizontal displacement Rotational displacement Remarks:	☐ Location shown on site map	Vertical displacement	☐ Deformation not evident
2. Degradation Remarks:	☐ Location shown on site map		☐ Degradation not evident

VII. LANDFILL COVERS (continued)		
I. Perimeter Ditches/Off-Site Discharge	☐ Applicable	☐ N/A
1. Siltation Arial extent Remarks:	☐ Location shown on site map Depth	☐ Siltation not evident
2. Vegetative Growth ☐ Vegetation does not impede flow Arial extent Remarks:	☐ Location shown on site map Type	☐ N/A
3. Erosion Arial extent Remarks:	☐ Location shown on site map Depth	☐ Erosion not evident
4. Discharge Structure Remarks:	☐ Functioning	☐ N/A

VIII. VERTICAL BARRIER WALLS	☐ Applicable	☐ N/A
1. Settlement Arial extent Remarks:	☐ Location shown on site map ☐ Depth	☐ Settlement not evident
2. Performance Monitoring ☐ Performance not monitored Frequency Head differential Remarks:	Type of monitoring	☐ Evidence of breaching
IX. GROUNDWATER/SURFACE WATER REMEDIES	☐ Applicable	☒ N/A
A. Groundwater Extraction Wells, Pumps, and Pipelines	☐ Applicable	☐ N/A
1. Pumps, Wellhead Plumbing, and Electrical ☐ Good condition ☐ All required wells located Remarks:	☐ Needs maintenance	☐ N/A

IX. GROUNDWATER/SURFACE WATER REMEDIES ☐ Applicable ☐ N/A

2. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances
☐ Good condition ☐ Needs maintenance
Remarks:

3. Spare Parts and Equipment
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks:

B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ☐ N/A

1. Collection Structures, Pumps, and Electrical
☐ Good condition ☐ Needs maintenance
Remarks:

2. Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances
☐ Good condition ☐ Needs maintenance
Remarks:

3. Spare Parts and Equipment
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks:

C. Treatment System ☐ Applicable ☒ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☐ Carbon adsorbers
☐ Filters
☐ Additive (e.g., chelation agent, flocculent)
☐ Others
☐ Good condition ☐ Needs maintenance
☐ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☐ Equipment properly identified
☐ Quantity of ground water treated annually
☐ Quantity of surface water treated annually
Remarks:

IX.C. GROUND WATER/SURFACE WATER REMEDIES (continued)

2. Electrical Enclosures and Panels (Properly rated and functional)
☒ N/A ☐ Good condition ☐ Needs maintenance
Remarks:

3. Tanks, Vaults, Storage Vessels
☒ N/A ☐ Good condition ☒ Proper secondary containment ☐ Needs maintenance
Remarks:

4. Discharge Structure and Appurtenances
☒ N/A ☐ Good condition ☐ Needs maintenance
Remarks:

5. Treatment Building(s)
☒ N/A ☐ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks:

6. Monitoring Wells (Pump and treatment remedy)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ All required wells located ☐ Needs maintenance ☒ N/A
Remarks:

D. Monitoring Data

1. Monitoring Data
☒ Has been routinely sampled on time; is no longer required ☐ Is of acceptable quality data reports not available

2. Monitoring Data Suggests
☐ Groundwater plume is effectively contained see text of Five-Year Review report

E. Monitored Natural Attenuation ☐ Applicable ☒ N/A

1. Monitoring Wells (Natural attenuation remedy)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ All required wells located ☐ Needs maintenance ☐ N/A
Remarks:

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

Current remedy per 2010 ROD is No Action.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

NA, there is no active O&M on this site.

XI. OVERALL OBSERVATIONS (continued)

C. Early Indicators of Potential Remedy Failure

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future.

N/A

D. Opportunities for Optimization

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

1. None
2.
3.
4.

AECOM

Individual Site Notes – Field Reconnaissance

Longhorn Army Ammunition Plant, Karnack, TX.

2013 Five Year Review

Site: LHAAP-012 **Date: 12/17/12**

Field Team: Dave Wacker, Gretchen McDonnell, Dave Gammans

Findings:	**Remedy:**
1. Unlocked Gate:	Needs New Lock, Securing
2. Numerous Subsidence Areas Marked with flagging:	GPS Coordinates Recorded
a. Central ~10'X12'	
b. West Edge three small areas ~10X20' and two combined at ~8'X40'	
c. North End ~40'X40'	
d. Northwest Mower ruts ~10'X30'.	
Most areas ~ 1 to 1.5 ft deep.	Backfill, Tamper, Regrade, Vegetate
3. Minor washout surface soil and grasses on east edge.	Grade, Vegetate
4. East Edge fence line old, former animal burrow.	Check for activity, backfill and grade
5. Monitoring Well Identification, Condition – Out of date	Confirm IDs, repainting, remarking, some locks, hinge repair (see well list)

Site: LHAAP-016 **Date: 12/17/12**

Field Team: Dave Wacker, Gretchen McDonnell, Dave Gammans

Findings:	**Remedy:**
1. Access Unrestricted @ Gate:	Needs Barbed Wire to limit access around gate
2. Signage Missing Along Fence line	Replace
3. Few, Small Subsidence Areas Marked with flagging	
a. Central, West 30'X30'	
b. Central, North ~40X10'	
Areas ~ 0.5 ft deep.	Backfill, Tamper, Regrade, Vegetate
4. Minor erosion surface soil, sparse vegetation esp.west edge	Grade, Vegetate
a. West 20'X15' and 50'X30'	
b. East 15'X30' and 10'X50'	
c. Northeast, Slight	
d. North, Slight	
5. Animal burrow. East Central near swale	Check for activity, backfill and grade
6. Monitoring Well Identification, Condition	Confirm IDs, repainting, remarking, growth clearing, some pad repairs, some locks, hinge repair (see well list)

Site: LHAAP-018/ 024 **Date: 12/19 and 20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Unlocked Gate	Needs New Lock, Securing
2. Gate Signage Illegible	Replace with new signs
3. Signage Missing Along Fence line	Replace
4. Few areas of Fence Have Excessive Vegetation	Clearing / Maintenance
5. Monitoring Well Identification, Condition – Out of date	Inspection, Confirm IDs, Repainting, Remarking, Locks, Repair or Abandon as needed

Site: Groundwater Treatment Plant (GWTP) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Rust Corrosion on Activated Carbon Vessels	Recondition, Repaint
2. Rust Corrosion on PK200B Tank	Recondition, Repaint
3. Rust Residue Below PK140 Influent Holding Tank Flange	Recondition, Repaint
4. System Optimization	Engineering Review
5. Level Probe Hydrochloric Acid Tank	Needs Engineering Review, Repair

Site: Former Pistol Range (LHAAP-004-R-01) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Daily Access/Security Logs	Review LUC Management Plan and Determine Fish and Wildlife Service and/or US Army Responsibility
2. Missing Signage, Gate Access	Review Plan As Above
3. Former Monitoring Well Abandonment	Research, Confirm, Possible Search

Site: Former Acid Plant (LHAAP-049) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	**Remedy:**
1. Daily Access/Security Logs	Review LUC Management Plan and Determine Fish and Wildlife Service and/or US Army Responsibility
2. Missing Signage, Access	Review Plan As Above
3. Monitoring Wells Identification, Condition	Research, Confirm IDs, Repainting, Remarking, Growth Clearing, Repair or Abandon as needed

APPENDIX G4: Photographs

AECOM

Photo Log

Longhorn Army Ammunition Plant, Karnack, TX.

2013 Five Year Review

Photo #	Date	Site	Description
101_1099.JPG	12/19/12	LHAAP-049	Site Area Looking Southwest with Monitoring Well 49WW04
101_1100.JPG	12/19/12	"	Remains of Buildings and General Site Area Looking South
101_1101.JPG	12/19/12	"	Concrete Cradles and Monitoring Well 49WW08 in Background Looking Southwest
101_1102.JPG	12/19/12	"	Concrete Cradles Looking South
101_1103.JPG	12/19/12	"	Typical Abandoned Pipe, Central on Site
101_1104.JPG	12/19/12	"	Site Area from Slight Hill Looking East
101_1105.JPG	12/19/12	"	Slight Ridge Area from Hill Looking West
101_1106.JPG	12/19/12	"	Typical Fish and Wildlife Service Warning Signs to Southeast of Site
101_1107.JPG	12/19/12	"	Typical Department of Army Warning Sign to Southeast of Site
101_1108.JPG	12/19/12	"	Remains of Buildings and Pipe Centrally Located Looking North
101_1109.JPG	12/19/12	"	Remains of Buildings Located to East and General Site Area Looking North
101_1110.JPG	12/19/12	"	Remains of Buildings and Stack Remnants Looking Northeast
101_1111.JPG	12/19/12	"	South-Central Concrete Structures Looking West
101_1112.JPG	12/19/12	"	General Site Conditions (former safety shower) Looking North
101_1113.JPG	12/19/12	LHAAP-049	Area near Monitoring Well 49WW05 Showing Need for Pad Clearing

Weather: overcast, moderate wind, temps low to hi 50's °F.

Field Team: David Gammans, Scott Beesinger

Camera Details: Kodak EasyShare M5350, 16 MP

Photograph Files Location: c:\Users\GammansD\Longhorn 5yr\Travel\field work forms\ Completed Site Forms\12-19-2012

Additional Comments:


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


NATIONAL
WILDLIFE
REFUGE
HUNTING ZONE
2
BOUNDARY
32
AREA
BEYOND
THIS
SIGN
CLOSED
All public entry prohibited
12/19/2012


RESTRICTED AREA
This installation has been declared a restricted area by authority of the Commanding Officer in accordance with the provisions of the directive issued by the Secretary of Defense on 20 August 1954, pursuant to the provisions of Section 21, Internal Security Act of 1950. Unauthorized entry is prohibited.
All persons and vehicles entering herein are liable to search. Photographing or making notes, drawings, maps, or graphic representations of this area or its activities are prohibited unless specifically authorized by the Commander. Any such material found in the possession of unauthorized persons will be confiscated.
12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


49
MW
05
12/19/2012

APPENDIX H: Pistol Range Supporting Documents

APPENDIX H1: Documents Reviewed

Documents Reviewed for Pistol Range

Complete Environmental Services, 2004. Correspondence from William R. Corrigan, III, addressed to Rose M. Zeiler, LHAAP Site Manager, Department of the Army, Subject: *Data from samples at Pistol Firing Range, Karnack, Texas*. July 6th.

Maley, Don, 1988. *Potential Hazardous Waste Site Preliminary Assessment*, EPA Form 2070-12. April.

Shaw, 2007. *Final Installation-Wide Baseline Ecological Risk Assessment, Volume I,* Longhorn Army Ammunition Plant, Karnack, TX, AR 2007 Vol 10 of 25 A, 00049542 - 00050415, 2007 Final-Instln-Baseline-EcoVol10of25.pdf. November.

Shaw, 2009. *Final Engineering Evaluation/Cost Analysis, Former Pistol Range, Longhorn Army Ammunition Plant, Karnack, Texas.* February.

Shaw, 2010. *Final Completion Report, Non-Time-Critical Removal Action at the Former Pistol Range, Longhorn Army Ammunition Plant, Karnack, Texas.* January.

Texas Commission on Environmental Quality (TCEQ), 1998, Interoffice Memorandum from Ronald R. Pedde to Remediation Division Staff, Subject: *Implementation of the Existing Risk Reduction Rule*, July 23rd.

TCEQ, 2006. *Update Examples of Standard No. 2, Appendix II Medium-Specific Concentrations*. March.

Thiokol Corporation, 1995. Letter from B. Singh/Thiokol to Administrative Contracting Officer, Subject: *Ref. Letter dated 7 June 1995, Subject: TNRCC Area of Concern – Lead Contamination at Pistol Firing Range*, July 20th.

U.S. Army, 2004. *Memorandum of Agreement Between the Department of the Army and the Department of the Interior for the Interagency Transfer of Lands at the Longhorn Army Ammunition Plant for the Caddo Lake National Wildlife Refuge, Harrison County, Texas.* April.

U.S. Army, 2010. *Final Proposed Plan for the Former Pistol Range, Longhorn Army Ammunition Plant, Karnack, Texas.* January.

APPENDIX H2: Five-Year Review Site Inspection Checklist

FIVE-YEAR REVIEW SITE INSPECTION CHECKLIST

Information may be completed by hand and attached to the five-year review report as supporting documentation of site status. "N/A" refers to "not applicable."

I. SITE INFORMATION

Site Name: Longhorn Army Ammunition Plant Site: LHAAP-004-R-01(Former Pistol Range)	Date of Inspection: Dec. 19, 2012
Location and Region: Karnack, TX; EPA Region 6	**EPA ID: TX6213820529**
Agency, office or company leading the five-year review: AECOM under contract to the U.S. Army	Weather/temperature: overcast, moderate wind, temps low to hi 50's °F.

Remedy Includes: (Check all that apply)
☐ Landfill cover/containment
☐ Access controls
☐ Institutional controls
☐ Ground water pump and treatment
NA Surface water collection and treatment
☒ Other – No Further Action

Attachments: ☐ Inspection team roster attached
Inspection Team Members: David D. Gammans, Scott Beesinger ☐ Site map attached

II. INTERVIEWS (Check all that apply)

1. O&M Site Manager | **Title** | **Date**
Name, Affiliation: Scott Beesinger | O&M Site Manager | Dec. 20, 2012

Interviewed: ☐ by mail ☒ at office ☐ by phone Phone no. (903)217-9954
Problems, suggestions: ☒ Report attached (Refer to Appendix H)

2. O&M Staff | **Title** | **Date**
Name, Affiliation: Ray Wagner | O&M Staff | Dec. 20, 2012

Interviewed: ☐ by mail ☒ at office ☐ by phone Phone no. (903)679-3448
Problems, suggestions: ☐ Report attached

II. INTERVIEWS (continued)

3. Local regulatory authorities and response agencies (i.e.; State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.). Fill in all that apply.

Agency
Contact ____________ ____________ ____________ ____________
Name Title Date Phone no.

Problems, suggestions: ☒ Report attached _(Refer to Appendix I)____________

Agency____________________(Refer to Appendix I)____________
Contact____________ ____________ ____________ ____________
Name Title Date Phone no.

Problems, suggestions: ☒ Report attached See Interview Record

4. Other interviews (optional) ☒ Report attached to Five-Year Review Report (Refer to Appendix I)

1. (Refer to Appendix I)
2.
3.
4.
5.

III. ONSITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. O&M Documents

☐ O&M Manual (see below)	☐ Readily available	☐ Up to date	☒ N/A
☐ As-built drawings	☐ Readily available	☐ Up to date	☒ N/A
☐ Maintenance logs	☐ Readily available	☐ Up to date	☒ N/A

Remarks:

2. Site-Specific Health and Safety Plan	☐ Readily available	☐ Up to date	☒ N/A
☐ Contingency plan/emergency response plan	☐ Readily available	☐ Up to date	☐ N/A

Remarks:

III. ONSITE DOCUMENTS & RECORDS VERIFIED (continued)

3. O&M and OSHA Training Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks: ________________

4. Permits and Service Agreements

☐ Air discharge permit	☐ Readily available	☐ Up to date	☒ N/A
☐ Effluent discharge	☐ Readily available	☐ Up to date	☒ N/A
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	☒ N/A
☐ Other permits	☐ Readily available	☐ Up to date	☒ N/A

Remarks:

5. Gas Generation Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

6. Settlement Monument Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

7. Ground Water Monitoring Records ☒ Readily available ☐ Up to date ☒ N/A

Remarks: U.S. Army Administrative Record (Monitoring Well Abandoned)

8. Leachate Extraction Records ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

9. Discharge Compliance Records

☐ Air	☐ Readily available	☐ Up to date	☒ N/A
☐ Water (effluent)	☐ Readily available	☐ Up to date	☒ N/A

Remarks: Sampled what frequency. Records maintained where

10. Daily Access/Security Logs ☐ Readily available ☐ Up to date ☒ N/A

Remarks:

IV. O&M COSTS

1. O&M Organization

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☒ Other (Example: Contractor for U.S. Army Corps of Engineers)

(Please see Section 4.0 of the Five-Year Review Report (2013) for cost information)

2. O&M Cost Records

☐ Readily available ☐ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate ___________ ☐ Breakdown attached

Total annual cost by year for review period, if available
(State unit here)

From Month year (Date) to ______ (Date) ______ (Total cost) ☐ Breakdown attached

From _________ (Date) to ______ (Date) ______ (Total cost) ☐ Breakdown attached

From _________ (Date) to ______ (Date) ______ (Total cost) ☐ Breakdown attached

From _________ (Date) to ______ (Date) ______ (Total cost) ☐ Breakdown attached

From _________ (Date) to ______ (Date) ______ (Total cost) ☐ Breakdown attached

3. Unanticipated or Unusually High O&M Costs During Review Period

Describe costs and reasons:
1. __
2. ______
3. ______
4. ______
5. ______

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. Fencing damaged ☐ Location shown on map ☐ Gates secure ☒ N/A
Remarks: Use as Wildlife Refuge. Limited access with gated dirt road and limited signage.

B. Other Access Restrictions

1. Signs and other security measures ☐ Location shown on map ☒ N/A
Remarks:

C. Institutional Controls

1. Implementation and enforcement

Site conditions imply ICs not properly implemented	☐ Yes	☒ No	☐ N/A
Site conditions imply ICs not being fully enforced	☐ Yes	☒ No	☐ N/A

Type of monitoring (e.g., self-reporting, drive by)

Frequency
Responsible party/agency NA
Contact

Name	Title	Date	Phone no.

Reporting is up-to-date	☐ Yes	☐ No	☐ N/A
Reports are verified by the lead agency	☐ Yes	☐ No	☐ N/A
Specific requirements in deed or decision documents have been met	☐ Yes	☐ No	☐ N/A
Violations have been reported	☐ Yes	☐ No	☐ N/A
Other problems or suggestions:	☐ Report attached		

2. Adequacy ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks: Site is listed in LUC plans listed 2007 Appendix B, and 2013. All construction activities at the Base must also be cleared by the environmental group to address any potential exposure issues.

D. General

1. Vandalism/trespassing ☐ Location shown on site map ☒ No vandalism evident
Remarks:

V.D ACCESS AND INSTITUTIONAL CONTROLS (continued)

2. Land use changes on site ☐ N/A
Remarks: None.

3. Land use changes off site ☐ N/A
Remarks: None, Caddo Lake Wildlife Refuge

VI. GENERAL SITE CONDITIONS

A. Roads ☒ Applicable ☐ N/A

1. Roads damaged ☐ Location shown on site map ☒ Roads adequate ☐ N/A
Remarks: Dirt road through site

B. Other Site Conditions
Remarks: Former Pistol Range Now Open Grassland Near Elevated Pine Woodlands.

VII. LANDFILL COVERS ☐ Applicable ☒ N/A

A. Landfill Surface

1. Settlement (Low spots) ☐ Location shown on site map ☐ Settlement not evident
Arial extent Depth
Remarks:

2. Cracks ☐ Location shown on site map ☐ Cracking not evident
Lengths Widths Depths
Remarks:

3. Erosion ☐ Location shown on site map ☐ Erosion not evident
Arial extent Depth
Remarks:

VII.A LANDFILL COVERS (continued)

4. Holes ☐ Location shown on site map ☐ Holes not evident
Arial extent Depth
Remarks:

5. Vegetative Cover ☐ Grass ☐ Cover properly established ☐ No signs of stress

☐ Trees/Shrubs (indicate size and locations on a diagram)
Remarks:

6. Alternative Cover (armored rock, concrete, etc.) ☐ N/A
Remarks:

7. Bulges ☐ Location shown on site map ☐ Bulges not evident
Arial extent Depth

Remarks:

8. Wet Areas/Water Damage ☐ Wet areas/water damage not evident

☐ Wet areas	☐ Location shown on site map	☐ Arial extent
☐ Ponding	☐ Location shown on site map	☐ Arial extent
☐ Seeps	☐ Location shown on site map	☐ Arial extent
☐ Soft subgrade	☐ Location shown on site map	☐ Arial extent

Remarks:

9. Slope Instability ☐ Slides ☐ Location shown on site map ☐ No evidence of slope instability

Arial extent

Remarks:

B. Benches ☐ Applicable ☐ N/A

1. Flows Bypass Bench ☐ Location shown on site map ☐ N/A or okay

Remarks:

VII.B LANDFILL COVERS (continued)		
2. Bench Breached Remarks:	☐ Location shown on site map	☐ N/A or okay
3. Bench Overtopped Remarks:	☐ Location shown on site map	☐ N/A or okay
C. Letdown Channels	☐ Applicable	☐ N/A
1. Settlement Arial extent Remarks:	☐ Location shown on site map Depth	☐ No evidence of settlement
2. Material Degradation Material type Remarks:	☐ Location shown on site map Arial extent	☐ No evidence of degradation
3. Erosion Arial extent Remarks:	☐ Location shown on site map Depth	☐ No evidence of erosion
4. Undercutting Arial extent Remarks:	☐ Location shown on site map Depth	☐ No evidence of undercutting
5. Obstructions Type ☐ Location shown on site map Size Remarks:	Arial extent	☐ No obstructions
6. Excessive Vegetative Growth ☐ No evidence of excessive growth ☐ Vegetation in channels does not obstruct flow ☐ Location shown on site map Remarks:	Type Arial extent	

VII. LANDFILL COVERS (continued)			
D. Cover Penetrations		☐ Applicable	☐ N/A
1. Gas Vents	☐ Active	☐ Passive	
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs maintenance	☐ N/A
Remarks:			
2. Gas Monitoring Probes			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☐ N/A
Remarks:			
3. Monitoring Wells (within surface area of landfill)			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☐ N/A
Remarks:			
4. Leachate Extraction Wells			
☐ Properly secured/locked	☐ Functioning	☐ Routinely sampled	☐ Good condition
☐ Evidence of leakage at penetration		☐ Needs O&M	☐ N/A
Remarks:			
5. Settlement Monuments	☐ Located	☐ Routinely surveyed	☐ N/A
Remarks:			
E. Gas Collection and Treatment		☐ Applicable	☐ N/A
1. Gas Treatment Facilities			☐ N/A
☐ Flaring	☐ Thermal destruction	☐ Collection for reuse	
☐ Good condition		☐ Needs Maintenance	
Remarks:			
2. Gas Collection Wells, Manifolds, and Piping			☐ N/A
☐ Good condition		☐ Needs Maintenance	
Remarks:			
3. Gas Monitoring Facilities (e.g., gas monitoring of adjacent homes or buildings)			☐ N/A
☐ Good condition		☐ Needs Maintenance	
Remarks:			

VII. LANDFILL COVERS (continued)			
F. Cover Drainage Layer		☐ Applicable	☐ N/A
1. Outlet Pipes Inspected Remarks:		☐ Functioning	☐ N/A
2. Outlet Rock Inspected Remarks:		☐ Functioning	☐ N/A
G. Detention/Sedimentation Ponds		☐ Applicable	☐ N/A
1. Siltation Remarks:	Arial extent Siltation not evident	Depth	☐ N/A
2. Erosion Remarks:	Arial extent Erosion not evident	Depth	
3. Outlet Works Remarks:	☐ Functioning	☐ N/A	
4. Dam Remarks:	☐ Functioning	☐ N/A	
H. Retaining Walls	☐ Applicable	☐ N/A	
1. Deformations Horizontal displacement Rotational displacement Remarks:	☐ Location shown on site map	Vertical displacement	☐ Deformation not evident
2. Degradation Remarks:	☐ Location shown on site map		☐ Degradation not evident

VII. LANDFILL COVERS (continued)		
I. Perimeter Ditches/Off-Site Discharge	☐ Applicable	☒ N/A
1. Siltation Arial extent Remarks:	☐ Location shown on site map Depth	☐ Siltation not evident
2. Vegetative Growth ☐ Vegetation does not impede flow Arial extent Remarks:	☐ Location shown on site map Type	☐ N/A
3. Erosion Arial extent Remarks:	☐ Location shown on site map Depth	☐ Erosion not evident
4. Discharge Structure Remarks:	☐ Functioning	☐ N/A

VIII. VERTICAL BARRIER WALLS	☐ Applicable	☐ N/A
1. Settlement Arial extent Remarks:	☐ Location shown on site map ☐ Depth	☐ Settlement not evident
2. Performance Monitoring ☐ Performance not monitored Frequency Head differential Remarks:	Type of monitoring	☐ Evidence of breaching
IX. GROUNDWATER/SURFACE WATER REMEDIES	☐ Applicable	☒ N/A
A. Groundwater Extraction Wells, Pumps, and Pipelines	☐ Applicable	☐ N/A
1. Pumps, Wellhead Plumbing, and Electrical ☐ Good condition ☐ All required wells located Remarks:	☐ Needs maintenance	☐ N/A

IX. GROUNDWATER/SURFACE WATER REMEDIES ☐ Applicable ☒ N/A
2. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances ☐ Good condition ☐ Needs maintenance Remarks:
3. Spare Parts and Equipment ☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks:
B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ☐ N/A
1. Collection Structures, Pumps, and Electrical ☐ Good condition ☐ Needs maintenance Remarks:
2. Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances ☐ Good condition ☐ Needs maintenance Remarks:
3. Spare Parts and Equipment ☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks:
C. Treatment System ☐ Applicable ☒ N/A
1. **Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☐ Air stripping ☐ Carbon adsorbers ☐ Filters ☐ Additive (e.g., chelation agent, flocculent) ☐ Others ☐ Good condition ☐ Needs maintenance ☐ Sampling ports properly marked and functional ☐ Sampling/maintenance log displayed and up to date ☐ Equipment properly identified ☐ Quantity of ground water treated annually ☐ Quantity of surface water treated annually Remarks:

IX.C. GROUND WATER/SURFACE WATER REMEDIES (continued)	
2.	**Electrical Enclosures and Panels** (Properly rated and functional) ☐ N/A ☐ Good condition ☐ Needs maintenance Remarks:
3.	**Tanks, Vaults, Storage Vessels** ☐ N/A ☐ Good condition ☒ Proper secondary containment ☐ Needs maintenance Remarks:
4.	**Discharge Structure and Appurtenances** ☐ N/A ☐ Good condition ☐ Needs maintenance Remarks:
5.	**Treatment Building(s)** ☐ N/A ☐ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks:
6.	**Monitoring Wells** (Pump and treatment remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs maintenance ☐ N/A Remarks:
D.	**Monitoring Data**
1.	**Monitoring Data** ☐ Is routinely sampled on time ☐ Is of acceptable quality data reports not available
2.	**Monitoring Data Suggests** ☐ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining (with minor exceptions, see text of Five-Year Review report
E.	**Monitored Natural Attenuation** ☐ Applicable ☐ N/A
1.	**Monitoring Wells** (Natural attenuation remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs maintenance ☐ N/A Remarks: No on-site monitoring wells.

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

Former Pistol Range used intermittently by security personnel for small arms target practice 1950s through 2004. The target area was a natural wooded slope, eastern side of the site. 2006 and 2007 investigations determined lead contamination near surface soil only environmental concern. 2009 non-time critical excavation of contaminated soil (lead concentrations exceeding 1,000 mg/kg), confirmatory sampling, and site restoration. Removal action made the site fully compatible with anticipated use as a wildlife refuge. One shallow groundwater MW, eastern portion near toe of target slope, abandoned. The 2010 ROD is no further action..

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

NA, this is a no further action site, with the exception of five year reviews.

XI. OVERALL OBSERVATIONS (continued)

C. Early Indicators of Potential Remedy Failure

Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future.

N/A

D. Opportunities for Optimization

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

1. None
2.
3.
4.

Individual Site Notes – Field Reconnaissance

Longhorn Army Ammunition Plant, Karnack, TX.

2013 Five Year Review

Site: LHAAP-012 **Date: 12/17/12**

Field Team: Dave Wacker, Gretchen McDonnell, Dave Gammans

Findings:	**Remedy:**
1. Unlocked Gate:	Needs New Lock, Securing
2. Numerous Subsidence Areas Marked with flagging:	GPS Coordinates Recorded
a. Central ~10'X12'	
b. West Edge three small areas ~10X20' and two combined at ~8'X40'	
c. North End ~40'X40'	
d. Northwest Mower ruts ~10'X30'.	
Most areas ~ 1 to 1.5 ft deep.	Backfill, Tamper, Regrade, Vegetate
3. Minor washout surface soil and grasses on east edge.	Grade, Vegetate
4. East Edge fence line old, former animal burrow.	Check for activity, backfill and grade
5. Monitoring Well Identification, Condition – Out of date	Confirm IDs, repainting, remarking, some locks, hinge repair (see well list)

Site: LHAAP-016 **Date: 12/17/12**

Field Team: Dave Wacker, Gretchen McDonnell, Dave Gammans

Findings:	**Remedy:**
1. Access Unrestricted @ Gate:	Needs Barbed Wire to limit access around gate
2. Signage Missing Along Fence line	Replace
3. Few, Small Subsidence Areas Marked with flagging	
a. Central, West 30'X30'	
b. Central, North ~40X10'	
Areas ~ 0.5 ft deep.	Backfill, Tamper, Regrade, Vegetate
4. Minor erosion surface soil, sparse vegetation esp.west edge	Grade, Vegetate
a. West 20'X15' and 50'X30'	
b. East 15'X30' and 10'X50'	
c. Northeast, Slight	
d. North, Slight	
5. Animal burrow. East Central near swale	Check for activity, backfill and grade
6. Monitoring Well Identification, Condition	Confirm IDs, repainting, remarking, growth clearing, some pad repairs, some locks, hinge repair (see well list)

Site: LHAAP-018/ 024 **Date: 12/19 and 20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	Remedy:
1. Unlocked Gate	Needs New Lock, Securing
2. Gate Signage Illegible	Replace with new signs
3. Signage Missing Along Fence line	Replace
4. Few areas of Fence Have Excessive Vegetation	Clearing / Maintenance
5. Monitoring Well Identification, Condition – Out of date	Inspection, Confirm IDs, Repainting, Remarking, Locks, Repair or Abandon as needed

Site: Groundwater Treatment Plant (GWTP) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	Remedy:
1. Rust Corrosion on Activated Carbon Vessels	Recondition, Repaint
2. Rust Corrosion on PK200B Tank	Recondition, Repaint
3. Rust Residue Below PK140 Influent Holding Tank Flange	Recondition, Repaint
4. System Optimization	Engineering Review
5. Level Probe Hydrochloric Acid Tank	Needs Engineering Review, Repair

Site: Former Pistol Range (LHAAP-004-R-01) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	Remedy:
1. Daily Access/Security Logs	Review LUC Management Plan and Determine Fish and Wildlife Service and/or US Army Responsibility
2. Missing Signage, Gate Access	Review Plan As Above
3. Former Monitoring Well Abandonment	Research, Confirm, Possible Search

Site: Former Acid Plant (LHAAP-049) **Date: 12/20/12**

Field Team: Dave Gammans, Scott Beesinger

Findings:	Remedy:
1. Daily Access/Security Logs	Review LUC Management Plan and Determine Fish and Wildlife Service and/or US Army Responsibility
2. Missing Signage, Access	Review Plan As Above
3. Monitoring Wells Identification, Condition	Research, Confirm IDs, Repainting, Remarking, Growth Clearing, Repair or Abandon as needed

APPENDIX H3: Photographs

AECOM

Photo Log

Longhorn Army Ammunition Plant, Karnack, TX.

2013 Five Year Review

Photo #	Date	Site	Description
101_1086.JPG	12/19/12	Pistol Range LHAAP-004-R-01	Southern Edge of Site Looking East
101_1087.JPG	12/19/12	"	Site Area Looking Northeast
101_1088.JPG	12/19/12	"	Site Area Looking Northwest
101_1089.JPG	12/19/12	"	Site Area Looking West
101_1090.JPG	12/19/12	"	Site Area Looking West
101_1091.JPG	12/19/12	"	Eastern Site Area and Former Target Area Location

Weather: overcast, moderate wind, temps low to hi 50's °F.

Field Team: David Gammans, Scott Beesinger

Camera Details: Kodak EasyShare M5350, 16 MP

Photograph Files Location: c:\Users\GammansD\Longhorn 5yr\Travel\field work forms\Completed Site Forms\12-19-2012

Additional Comments:


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012


12/19/2012

APPENDIX I: Interview Forms

INTERVIEW RECORD

Site Name: Longhorn Army Ammunition Plant, Karnack, TX		**EPA ID No.:**	
Subject: 5-Year Review Information Survey - LHAAP		**Time:** 2:39 PM	**Date:** 02/02/13
Type: ☐ Telephone ☐ Visit X Other - Email **Location of Visit:** NA		☐ Incoming	☐ Outgoing

Contact Made By:

Name: Thomas Fogg	**Title:** Task Manager	**Organization:** AECOM 112 East Pecan St. Suite 400 San Antonio, TX 78205 508-888-2565 Thomas.fogg@aecom.com

Individual Contacted:

Name: Ms. Judith Johnson	**Title:** Member	**Organization:** RAB
Telephone No: 903-679-3130 **Fax No:** **E-Mail Address:** judithjohnson@webtv.net	**Street Address:** **City, State, Zip:**	

Summary Of Conversation

Please direct questions or comments regarding this survey to Dr. Thomas Fogg (at the address listed above).

1. Are you familiar with the following sites: Site LHAAP-12; Site LHAAP-16; Sites LHAAP-18/24; Site LHAAP-49; Site LHAAP-004-R-01/Pistol Range?

   Yes, site 12 is ready to transfer, once the MOA for maintenance/monitoring is in place with the USFWS. All the other sites are high priority sites and we want to know if the remedies are doing what you predicted for all the sites.

2. What is your overall impression of the project? (general sentiment)

   We think the project has not gone well. Our impression is that Longhorn AAP has not been a priority for the Army. However, the real display of interest was by their contractor, Shaw Environmental. There seemed to be no interest at all. We are persuaded that Shaw's evaluations and remedies were calculated to do the least amount of work possible to collect their fees and leave the community with a half done job. Sorry, but each meeting with Shaw was boring, avoided real issues and costs and left our group more confused and frustrated than the meeting before.

3. What effects have site operations had on the surrounding community?

   There are more questions and concerns raised than relieved about contamination at the site and the inability of the public to use lands that should be included in the Refuge. One thing everyone in the community understands there are contaminants in the ground at Longhorn AAP that have the potential of entering Caddo Lake or affecting the ground water in the area. Until the Army address those concerns completely and has a plan to mitigate or remove the contamination (a plan everyone understands) the surrounding community is not going to be happy not voicing their concerns.

4. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.

   One glaring fact stands out in local's minds when assessing operations. Shaw Environmental was not a member of our community. Shaw received $1.3 billion in U. S. Government contracts last year. They could have at least done something for Karnack Schools (token donation for environmental education since they are in that *business). They did not help with any charitable function or interact in any way with the community. They were there to help quite the opposition in the RAB meetings. They seemed to talk down to the local folks. Why didn't Shaw discuss ways to make locals part of the solution and help local endeavors. Is it cheaper to pump and treat potable water from government wells or use Karnack Water Supply water? If its just as cost effective to use our water utility, then why can't the local community benefit from any operations? It seems the Army is going to be around for awhile cleaning up. Is it cheaper to use Panola Harrison's connection with SWEPCO or for the Army to continue to use the high power line and old transformer? We are all share holders in Panola Harrison Electrical Coop. A few dollars would be nice in our community if the out come in overall costs are equal. The Army and there new contractor has the opportunity now to be more of a community member. This will benefit Refuge Manager at Caddo Lake NWR and it would be an excellent time to establish a fresh relationship with the Refuge and become better partners with all of us. Dave Wacker and AECom seem like good people and want to do a good job. We don't want to squander any good will that can be built on.*

5. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency responses from local authorities? If so, please give details.

   Yes, Antoine Cjkowski and his band of heathens stole a bulldozer from the Refuge and a assortment of tools and equipment from Shaw last year. The Refuge law enforcement, in coordination with the Harrison County Sheriff's Office, recovered all the stolen items and jailed the outlaws. The Refuge has excellent emergency response folks. Three employees are volunteer fire fighters (two of them are EMT"S). It would serve the Army and their contractors well to work closely with the Refuge staff in coordinating a crime prevention plan and gaining their confidence. The Refuge has cultivated a close relationship with the HCSO through a MOA and is one of the most crime free areas around the lake.

6. Do you feel well informed about the site's activities and progress?

   Shaw talked a lot but I did not have a understanding of what they said when I left the RAB meetings.

7. Do you have any comments, suggestions, or recommendations regarding the project?

   We need to all come to agreement, the Army and their contractors, the Regulator (EPA, TCEQ), the USFWS (Refuge) and the local community on what needs to be done and have an understanding that it will be done.

INTERVIEW RECORD

Site Name: Longhorn Army Ammunition Plant, Karnack, TX		**EPA ID No.:**	
Subject: 5-Year Review Information Survey - LHAAP		**Time:**	**Date: 2/12/13**
Type: ☐ Telephone ☐ Visit X Other - Email **Location of Visit:** NA		☐ Incoming	☐ Outgoing

Contact Made By:

Name: Thomas Fogg	**Title:** Task Manager	**Organization:** AECOM 112 East Pecan St. Suite 400 San Antonio, TX 78205 508-888-2565 Thomas.fogg@aecom.com

Individual Contacted:

Name: Mr. Paul Bruckwicki	**Title:**	**Organization:** USFWS
Telephone No: (903) 679-9144 **Fax No:** **E-Mail Address:** Paul_bruckwicki@fws.gov	**Street Address:** **City, State, Zip:**	

Summary Of Conversation

Please direct questions or comments regarding this survey to Dr. Thomas Fogg (at the address listed above).

1. Are you familiar with the following sites: Site LHAAP-12; Site LHAAP-16; Sites LHAAP-18/24; Site LHAAP-49; Site LHAAP-004-R-01/Pistol Range?

   Yes

2. What is your overall impression of the project? (general sentiment)

   The Facility is in a transition from the previous Performance Based Contract (PBC) contractor to the current contractor.

3. Have there been routine communications or activities (site visits, inspections, reporting activities, etc.) conducted by your office regarding the site? If so, please give purpose and results.

   Attend Monthly Manager's Meeting to discuss these sites as well as other sites involved in the cleanup at LHAAP/Caddo Lake NWR. Accompany contractor, EPA, TCEQ, USGS and ACE during various sampling events and field activities.

4. Have there been any complaints, violations, or other incidents related to the site requiring a response by your office? If so, please give details of the events and results of the responses.

   Yes. The local community has voiced its frustration repeatedly concerning the status of the remaining Army sites and when cleanup of those sites will be complete so that they can be transferred to the FWS. The public is also concerned about the remaining water rights associated with the facility. The FWS works with the Army to help alleviate the public concern about the remaining sites and the disposition of the remaining Government's water rights.

5. Do you feel well informed about the site's activities and progress?

   Yes

6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

   The USFWS continues to operate under the belief that most of the parcels of property remaining at the former LHAAP will eventually have remedies in place and that over time it will be shown that these remedies or remedial actions are operating properly and successfully and that the individual sites will be transferred from the Army to the FWS.

INTERVIEW RECORD

Site Name: Longhorn Army Ammunition Plant, Karnack, TX	**EPA ID No.:**	
Subject: 5-Year Review Information Survey - LHAAP	**Time:** 4:56 PM	**Date:** 02/06/13
Type: ☐ Telephone ☐ Visit X Other - Email **Location of Visit:** NA	☐ Incoming	☐ Outgoing

Contact Made By:

Name: Thomas Fogg	**Title:** Task Manager	**Organization:** AECOM 112 East Pecan St. Suite 400 San Antonio, TX 78205 508-888-2565 Thomas.fogg@aecom.com

Individual Contacted:

Name: Mr. Rich Mayer, P.G.	**Title:** Sr. Project Engineer	**Organization:** USEPA
Telephone No: 214-665-7442 **Fax No:** **E-Mail Address:** mayer.richard@epa.gov	**Street Address:** 6PD-F USEPA Region 6 1445 Ross Avenue, Suite 1200 Dallas, Texas 75202	

Summary Of Conversation

Please direct questions or comments regarding this survey to Dr. Thomas Fogg (at the address listed above).

1. Are you familiar with the following sites: Site LHAAP-12; Site LHAAP-16; Sites LHAAP-18/24; Site LHAAP-49; Site LHAAP-004-R-01/Pistol Range?

   Yes.

2. What is your overall impression of the project? (general sentiment)

   Project is progressing better since new contractor (AECOM) has been aboard. Great improvement in the public and RAB meetings. Technical meetings are better also.

3. Have there been routine communications or activities (site visits, inspections, reporting activities, etc.) conducted by your office regarding the site? If so, please give purpose and results.

   Yes, over the past year EPA has performed the tree coring sampling at Sites, 16, 17 & 18/24; split groundwater sampling at 18/24; well redevelopment and sampling at Sites 27 & 54; and 5 year review inspections for the sites identified in question 1 above.

4. Have there been any complaints, violations, or other incidents related to the site requiring a response by your office? If so, please give details of the events and results of the responses.

   No generally speaking. There is an administrative record, but it was obvious that the administrative record hasn't been well maintained when documentation that has been requested for years could not be found until an employee from the USACE that had worked on the site in the early years started working on the site again. This employee has done a great job of locating a lot of very important information that should have been in the administrative record. The administrative record is currently being updated due to the employee's diligence.

5. Do you feel well informed about the site's activities and progress?

   Yes.

6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

   Need to have an organized data base for each site so that the historical sampling results can be easily reviewed, especially for the groundwater. Also, EPA believes that the past contractor mislead the LHAAP management team by informing them that pumps in ICTs were working properly. In the WTP Quarterly reports, they stated that the water levels were too low for the pumps to produce (which may have been the case sometimes). However, water level data and communication with site operators indicate that many of those pumps have been broken for years and requests to replace them were ignored. AECOM has replaced all of the broken pumps since starting working on the site to eliminate that problem. In addition, the groundwater treatment plant was not properly maintained in recent years and some of the air control devices were not working. AECOM has recently done repairs to the many parts of the plant.

   Also, this site is very unusual in that there are some groundwater monitoring wells in which the concentrations of contaminants vary by several orders of magnitude between sampling events. I have never experienced this phenomena at any other site in my 26 years of experience.

INTERVIEW RECORD

Site Name: Longhorn Army Ammunition Plant, Karnack, TX		**EPA ID No.:**	
Subject: 5-Year Review Information Survey - LHAAP		**Time:** 4:38PM	**Date:** 02/03/13
Type: ☐ Telephone ☐ Visit X Other - Email **Location of Visit:** NA		☐ Incoming ☐ Outgoing	

Contact Made By:

Name: Thomas Fogg	**Title:** Task Manager	**Organization:** AECOM 112 East Pecan St. Suite 400 San Antonio, TX 78205 508-888-2565 Thomas.fogg@aecom.com

Individual Contacted:

Name: Mr. Richard LeTourneau	**Title:** Member	**Organization:** RAB
Telephone No: **Fax No:** **E-Mail Address:** richardoii@aol.com	**Street Address:** **City, State, Zip:**	

Summary Of Conversation

Please direct questions or comments regarding this survey to Dr. Thomas Fogg (at the address listed above).

1. Are you familiar with the following sites: Site LHAAP-12; Site LHAAP-16; Sites LHAAP-18/24; Site LHAAP-49; Site LHAAP-004-R-01/Pistol Range?

   Yes, I am familiar with the sites.
   I would ask that, inclusive of all the sites with defined remedies, what has been the measured success of the chosen remedies for each site.

2. What is your overall impression of the project? (general sentiment)

   I had a poor impression of the communication with Shaw Environmental. My question is this: Is AECOM in the process of reevaluating the remedies? I believe that Shaw became overwhelmed by the project and felt they should quit long ago, rather than completing their contract.

3. What effects have site operations had on the surrounding community?

   The past effects of Shaw's actions was poor communications with lay persons of this community. I think one of the greatest concerns of the community is the potential for future contamination of both groundwater and runoff into applicable creeks and greater Caddo Lake. There needs to be valid and scientific answer to the question of residual seepage into the groundwater, or changes in aquifer levels or routes.

4. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.

   I feel that most people in the community feel hope that a new era is upon us, that AECOM is a good and reputable company, and that there is hope for a new level of transparency, honesty, communication and cooperation.

5. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency responses from local authorities? If so, please give details.

   It is my understanding that in the past, some trespassers have been caught. It is also my understanding that there was some theft of heavy equipment and tools and that the perpetrators were caught.

6. Do you feel well informed about the site's activities and progress?

   In the past, there was poor communications with Shaw Environmental and the Army. Maybe it was a lack of desired information. I see hopeful signs that this will be much improved with AECOM.

7. Do you have any comments, suggestions, or recommendations regarding the project?

   Openness, honesty, transparency and good communication, whether the truthful answers are good or bad, is a necessity.

INTERVIEW RECORD

Site Name: Longhorn Army Ammunition Plant, Karnack, TX		**EPA ID No.:**	
Subject: 5-Year Review Information Survey - LHAAP		**Time:** 2:39 PM	**Date:** 02/02/13
Type: ☐ Telephone ☐ Visit X Other - Email **Location of Visit:** NA		☐ Incoming ☐ Outgoing	

Contact Made By:

Name: Thomas Fogg	**Title:** Task Manager	**Organization:** AECOM 112 East Pecan St. Suite 400 San Antonio, TX 78205 508-888-2565 Thomas.fogg@aecom.com

Individual Contacted:

Name: Ms. Rose Zeiler	**Title:** Member	**Organization:** U.S. Army
Telephone No: 479-635-0110 **Fax No:** **E-Mail Address:** rose.zeiler@us.army.mil	**Street Address:** Site Manager's Office Longhorn Army Ammunition Plant PO Box 220 727 South Brooklyn Road Ratcliff, AR 72951	

Summary Of Conversation

Please direct questions or comments regarding this survey to Dr. Thomas Fogg (at the address listed above).

1. Are you familiar with the following sites: Site LHAAP-12; Site LHAAP-16; Sites LHAAP-18/24; Site LHAAP-49; Site LHAAP-004-R-01/Pistol Range?

   Yes

2. What is your overall impression of the project? (general sentiment)

   The interim remedies at Sites 12, 16 and 18/24 are functioning well.

   The Site 12 final remedy of MNA appears to be effective and the landfill cover and well field is in good condition.

   The Site 16 interim remedies are functioning well. The landfill cover is well maintained, and the groundwater monitoring network is in good condition.

   The Site 18/24 is maintained as is the well field and groundwater monitoring and collection system.

   The Groundwater Treatment Plant and the water collection system that collects, stores, treats and discharges groundwater from Sites 16 and 18/24 is being maintained and actively repaired and/or upgraded as needed.

   Although Sites 49 and the Pistol Range have no remedies, the uses of the sites remain consistent with their risk assessment assumptions and the "Suitability for Non-residential Use" notifications filed in Harrison County.

   All of these sites remain in Army control but lie within the boundary of the Caddo Lake National Wildlife Refuge and, as such, exist within a federally-administered facility with an on-site federal presence.

3. Is the remedy functioning as expected? How well is the remedy performing?

   The remedies for Sites 12, 16 and 18/24 are functioning as intended and remain protective of human health and the environment for the remedial objectives they address. See response to #1 above.

   Surface water samples collected in Harrison Bayou indicate that there has been no unacceptable release to the Bayou from these sites. Containment of the source area plume within the ICT at Site 18/24 is effective in *protecting surface water and is performing as intended. Groundwater monitoring along the creek also demonstrates its effectiveness.*

Similarly the groundwater extraction at Site 16 has effectively controlled the highly contaminated portions of the plume. Although there is some movement of the plume past the extraction line, there has been no exceedance in surface water.

Site 12 MNA reports indicate the plume concentration is decreasing.

4. What does the monitoring data show? Are there any trends that show contaminant levels are decreasing?

   Yes the overall trends are decreasing on 12, 16, and 18/24. Site 12 really has only one well that has hits and it is decreasing. The groundwater reports for Sites 16 and 18/24 also indicate that contaminants are decreasing. There is some movement of the plume past the extraction line at Site 16 and some movement of the plume past the extraction boundary to the southwest, northwest and northeast at Site 18/24. The plume movement at Site 16 and Site 18/24 will be addressed with implementation of the final remedy at these two sites.

5. Is there a continuous on-site O&M presence? If so, please describe staff and activities. If there is not a continuous on-site presence, describe staff and frequency of site inspections and activities.

   Yes, the Army's contractor is present at the GWTP several days each week and they conduct regular inspections and maintenance on the wells, caps and groundwater collection and treatment systems that support remedies at Sites 12, 16, and 18/24. Maintenance includes mowing on all three sites.

6. Have there been any significant changes in the O&M requirements, maintenance schedules, or sampling routines since start-up or in the last five years? If so, do they affect the protectiveness or effectiveness of the remedy? Please describe changes and impacts.

   Over the last several years it has become apparent that the life of the groundwater treatment plant and collection (and pumping) systems would be required longer than previously anticipated. Additionally, because of the age of the equipment associated with those systems, a more robust inspection and maintenance protocol was put into place with the new environmental contract in the summer of 2012.

   Wells in the Sites 12, 16 and 18/24 well field have been inspected maintained and repaired as needed. All wells have been or are in the process of being repainted and numbered, and bollards, pads, well protective casings, locking mechanisms, well identifications, etc. have been repaired or replaced as required.

   All pumps in the Sites 16 and 18/24 extraction have been inspected and repaired or replaced. Although some were non-functioning or in need of some repair, the overall protectiveness of the remedies in addressing their objectives remains. The changes expected as a result of these repairs and replacements is enhancement in effectiveness of the functioning remedies along with a heightened ability to evaluate final remedy alternatives.

   Sampling SOPs and training documentation are being updated and a YSI (groundwater quality meter) SOP was developed to help ensure the equipment is being properly calibrated during sampling events.

   The monitoring list at Site 18/24 has increased from 16 to 23 and now 25 monitoring wells semi-annually and 6 annually. The increase in the monitoring network does not affect the protectiveness or effectiveness of the remedy but provides confirmation of the nature and extent of contamination and will assist in the selection and application of the final remedy.

   The monitoring program at Site 12 reduced from quarterly to semiannually to annually over the last five years. Three existing wells were added into the program for groundwater elevations only and the sampling was changed to a wetter season in response to TCEQ questions regarding uncertainty in groundwater flow patterns and the affect of time of year on groundwater results. TCEQ also requested a change back to semi-annual sampling. This request will be evaluated during this 5YR and will be influenced by results of the change in sampling season and the addition of the 3 existing wells for groundwater elevations. These issues and changes do not affect the protectiveness of the remedy, but will allow for a better evaluation of seasonal changes in the plume and will tell whether the present well locations are adequate to fully evaluate the MNA remedy at this site.

7. Have there been unexpected O&M difficulties or costs at the site since start-up or in the last five years? If so, please give details.

Because of the age of the well fields and groundwater treatment plant, and the fact that the system may be required for a longer period of time than originally envisioned, a more rigorous O&M plan was put into place with a new environmental contract in 2012. A major unexpected O&M difficulty was the failure of the scrubber blower unit which resulted in damage to the scrubber unit.

8. Have there been opportunities to optimize O&M, or sampling efforts? Please describe changes and resultant or desired cost savings or improved efficiency.

Yes – see answer to the #7.

Optimizing sampling efforts at Sites 16 and 18/24 is not realistic at this time because final remedies are not yet in place. Additional data, particularly for Site 18/24 is required and all systems must be maintained and operational so that a final remedy can be cost effectively selected. Current sampling at Sites 16 and 18/24 is being conducted concurrently to achieve cost savings and improved efficiency.

The trade-off between increased O&M and/or sampling costs and improved efficiency has not yet been evaluated because improvement and the results of those improvements are still underway. Additionally, the failure of the scrubber blower and scrubber unit and the plan forward for the GWTP are still being evaluated.

9. Do you have any comments, suggestions, or recommendations regarding the project?

No.

INTERVIEW RECORD						
Site Name:	Longhorn AAP IRP Sites LHAAP-012, -016, -018/024, -049 and Pistol Range		**EPA ID No.:**	TX6213820529		
Subject:	5-Year Review Report Interview		**Time:**	15:00	**Date:**	20-Dec-12

Interview Type: Meeting
Telephone Call: N/A
Meeting Location: Groundwater Treatment Plant, LHAAP, Karnack, TX.

Interviewer Information					
Name:	David Gammans	**Title:**	Senior Hydrogeologist	**Organization:**	AECOM
Name:		**Title:**		**Organization:**	

Interviewee Information					
Name:	Scott Beesinger	**Title:**	GWTP Operator	**Organization:**	AECOM
Telephone No.:	(903)217-9954	**Street Address:**	15,600 FM 134		
Fax No.:		**City, State, Zip:**	Karnack, Tx. 75661		
E-Mail Address:	Scott.Beesinger@aecom.com				

Summary of Conversation

Background Information Not aware of any problems or changes at sites LHAAP-049 (former Acid Plant) or LHAAP-004-R-01 (former Pistol Range)

1. What is your overall impression of the project? Good, all indications are that the remedies are working. Most problems from last five-year review have been corrected. Since AECOM has taken over the project there has been a more focused approach with renewed project management especially on operations and supplies. Routine maintenance has kept the project successful.

2. What effects have site operations had on the surrounding community? The community has varying opinions on the project. There is approximately a 50 - 50 split by those who think the level of attention and protectiveness is awesome, to those who have reservations.

3. Are you aware of any community concerns regarding the sites or their operation or administration? None Specific

4. Are you aware of any events, incidents or activities at the sites such as vandalism, trespassing or emergency response from local authorities? Only vandalism etc. in past five years was at the LHAAP-016 pump house where supplies were stolen. There have been a few other minor tresspassing events.

Construction Considerations

1. What is the current status of construction (e.g., budget and schedule)? Under Review

2. Have any problems been encountered which required, or will require, changes to this remedial design? Site LHAAP-018/024 only: Previous changes utilizing collector trenches for injection of treated water did not work well. Sprinkler system functions properly and efficiently.

3. Have any problems or difficulties been encountered which have impacted construction progress or implementability? Not Applicable (see above)

4. Do you have any comments, suggestions or recommendations regarding the project (i.e., project design construction documents, constructability, management, regulatory agencies, etc.)? Recommend no extreme changes.

Performance, Operation and Maintenance Problems

1. Are the remedies functioning as expected? Yes / No **How well are the remedies performing?** Yes, Renewed project focus making significant improvements on system performance. Good equipment condition.

2. Is there a continuous on-site O&M presence? If so, please describe staff and activities. Yes, except for weekends when staff is on call. Scott Beesinger O&M Site Manager, Ray Wagner O&M Staff.

INTERVIEW RECORD					
Site Name:	Longhorn AAP IRP Sites LHAAP-012, -016, -018/024, -049 and Pistol Range	**EPA ID No.:**	TX6213820529		
Subject:	5-Year Review Report Interview	**Time:**	15:00	**Date:**	20-Dec-12

3. Have there been any significant changes in the O&M requirements, maintenance schedules, or sampling routines in the last five years? If so, do they affect the protectiveness or effectiveness of the remedy? Please describe changes and impacts. All O&M procedures are presently under revision and optimization. Groundwater sampling locations and schedules have changed but have not significantly impacted O&M operations.

4. Have there been any unexpected O&M difficulties or costs at the sites in the last five years? Mostly routine maintenance of aging equipment. Hydrochloric Acid tank repairs and Air Scrubber burned out.

5. Have there been opportunities to optimize O&M during the last five years? Please describe changes and resultant or desired cost savings or improved efficiency. As previously mentioned, all O&M procedures are presently under revision and optimization. At the LHAAP-016 landfill bioremediation was done quite a while ago, could possibly be used again. Recent improvements in extraction well pumps (maintenance, lowering etc) have significantly improved extraction rates. At LHAAP-018/024 previous use of collector trenches for injection of treated water did not seem to work. Three Tier approach for GWTP effluet (creek when flow allows, sprinkler system and lastly lined settling pond) seems to work well.